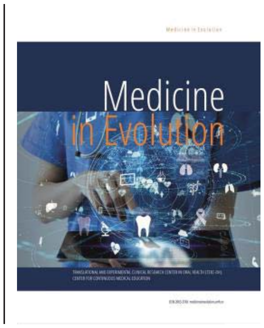
Cephalometric analysis of the upper airway in adult Caucasians with skeletal Class I and Class II malocclusion



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Abstract

Aim and objectives: The aim of our study was to evaluate the nasopharyngeal and oropharyngeal anteroposterior space width in adult Caucasians with skeletal Class I and Class II malocclusion, using several linear cephalometric measurements.

Material and methods: Our retrospective study included a total of 60 lateral cephalometric radiographs from adult patients (31 females and 29 males), with skeletal Class I and skeletal Class II malocclusion, aged 18 to 34 years. The skeletal pattern was assessed using Steiner's ANB angle. The pharyngeal width measurements included the width of the nasopharynx, upper pharyngeal airway width (UPAW), middle pharyngeal airway width (MPAW) and lower pharyngeal airway width (LPAW).

Results and conclusions: The mean values of UPAW and MPAW in the skeletal Class II male subgroup were significantly lower than the mean values in the female subgroup. The mean values of LPAW in the skeletal Class I male subgroup were significantly higher than the mean values in the female subgroup. The mean values of MPAW and LPAW in the skeletal Class I male subgroup were significantly higher than the mean values in skeletal Class II male subgroup.

Keywords: upper airway, skeletal Class I, skeletal Class II, cephalometric analysis

INTRODUCTION

The pharynx, a segment of the upper airways, is a muscular tube divided into three anatomical regions, according to their location: the nasopharynx, oropharynx, and hypopharynx (laryngopharynx).

The nasal cavities extend posteriorly with an elongated space, the nasopharynx, which is delimited by the base of the skull and the posterior surface of the soft palate. The hypertrophy of the adenoid tonsils, located on the posterosuperior wall of the nasopharynx, is one of the most frequent causes for the constriction of the upper respiratory tract. The middle part of the pharynx, the oropharynx, is the space located behind the oral cavity, inferior to the soft palate region and above the superior border of the epiglottis. The hypopharynx is the most inferior region of the pharynx and is delimited caudally by the inferior border of the cricoid cartilage.

The relationship between the respiratory function and the growth and development of the craniofacial structures has long been debated in the literature, but with contradictory results. There are authors that didn't find any correlation between the characteristics of the craniofacial complex and the pharyngeal region [1–4], while other authors found significant relationships between these structures [5–8].

Being able to identify the predisposition to respiratory disorders based on the craniofacial skeletal patterns, or the predisposition to malocclusion based on the alterations in the respiratory function (e.g., oral breathing, sleep apnea) or on the factors that cause upper airway obstruction (e.g., hypertrophied adenoids, infections, allergies), could provide the clinicians with the proper tools for early diagnosing these anomalies [1,9–11].

When compared to CBCT scans, two-dimensional radiographic images cannot offer data about the depth or the volume of the anatomic structures. Even with these limitations, lateral cephalograms continue to be a useful standard complementary exam for analyzing the craniofacial and the pharyngeal airway morphology, because they are accessible, reliable and require exposure to very low doses of radiation [8,12].

Aim and objectives

The aim of our study was to evaluate the nasopharyngeal and oropharyngeal anteroposterior space width in adult Caucasians with skeletal Class I and Class II malocclusion, using several linear cephalometric measurements.

MATERIAL AND METHODS

Our retrospective study included a total of 60 lateral cephalometric radiographs from adult patients (31 females and 29 males), with skeletal Class I and skeletal Class II malocclusion, aged 18 to 34 years. The patients were selected from the database in our private dental office and from the Department of Orthodontics and Dento-Facial Orthopedics, Faculty of Dental Medicine, "Victor Babeş" University of Medicine and Pharmacy Timişoara. All the patients agreed to participate in medical research and they all signed an informed consent. The patients were included in the study according to the following criteria: Romanian Caucasian adult patients, without upper airway obstruction, with no respiratory disorders, with posterior dental arch integrity (no extractions, with the exception of the third molars), without prior orthodontic treatment or orthognathic surgery.

Investigation method

The radiographs were digitally analyzed using the AudaxCeph 5 Essentials orthodontic software suite. We used a custom cephalometric analysis for linear and angular measurements, with the following skeletal cephalometric landmarks: N (nasion), Point A, Point B, ANS (anterior nasal spine), PNS (posterior nasal spine), S (sella) and Ba (basion).

The skeletal pattern of each patient was assessed using Steiner's ANB angle, which is obtained by subtracting the value of SNB angle from the value of SNA angle. The patients were divided in two groups: skeletal Class I group (ANB = 2° ± 2°) and skeletal Class II group (ANB > 4°). A cephalometric tracing with the angular measurements is illustrated in Figure 1.

For the analysis of the width of the nasopharynx (PNSp-Ad), we used two constructed landmarks (PNSp and Ad), which resulted from the intersection of the radiographic contour of the soft tissue of the nasopharynx and a line connecting PNS with the midpoint (M) of the sella-basion line (S-Ba). PNSp was defined as the intersection point between the PNS-M line and the anteroinferior region of the radiographic contour of the nasopharynx. Ad (adenoid point) was defined as the intersection point between the PNS-M line and the posterosuperior area of the radiographic contour of the nasopharynx. The upper pharyngeal airway width (UPAW), the border between the nasopharynx and the oropharynx, was defined by the intersection of the posterior extension of the palatal plane (ANS-PNS) and the radiographic contour of the oropharynx; one intersection point is located on the posterior surface of the soft palate and the other, on the posterior pharyngeal wall. In order to characterize the middle pharyngeal airway width (MPAW), we chose to measure the narrowest width between the posterior surface of the soft palate and the posterior pharyngeal wall, along a line parallel with the palatal plane. The lower pharyngeal airway width (LPAW) was measured along a line parallel with the palatal plane, between the posterior pharyngeal wall and a point located at the intersection of the contour of the mandible and the base of the tongue. All the landmarks and linear measurements are illustrated on the cephalometric tracing in Figure 2.

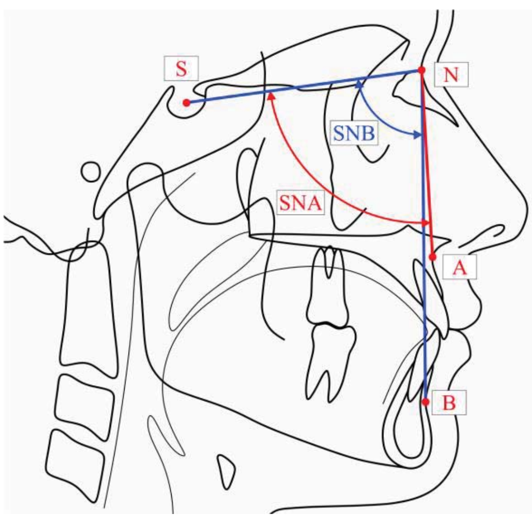

Figure 1. Cephalometric tracing illustrating the angular measurements SNA and SNB

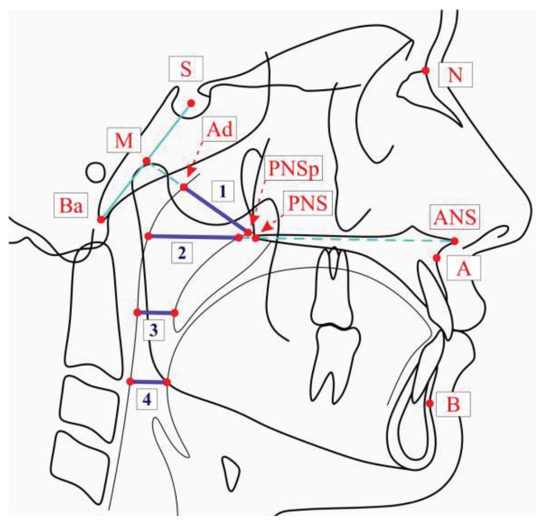

Figure 2. Cephalometric tracing illustrating the linear measurements: 1 – PNSp-Ad; 2 – UPAW; 3 – MPAW; 4 – LPAW

Statistical analysis

The data were statistically analyzed using the IBM SPSS Statistics for Windows software package (IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp). Descriptive statistics were generated for all the measured variables. Independent-samples t-tests were used to test for differences in the examined variables between males and females with the same sagittal skeletal pattern, and between males and females belonging to different skeletal groups (Class I vs Class II). We considered the independent-samples t-test to be statistically significant at $p < 0.05$.

One outlier was identified in the MPAW Class I male group, as assessed by inspection of boxplots. We decided to include the outlier in the data set, because the outlier was not extreme and it did not affect the outcome of the study. The measured variables were normally distributed, as assessed by Shapiro-Wilk's test ($p > 0.05$). There was homogeneity of variances for all the measured variables, as assessed by Levene's test for equality of variances ($p > 0.05$), with only two exceptions. There was no homogeneity of variances for PNSp-Ad and MPAW when comparing all the patients (males and females overall) in skeletal Class I group and Class II group, therefore a Welch t-test was used to analyse the data.

RESULTS

The sample distribution by age and gender (31 females and 29 males) in skeletal Class I group and skeletal Class II group is shown in Figure 3 and Figure 4.

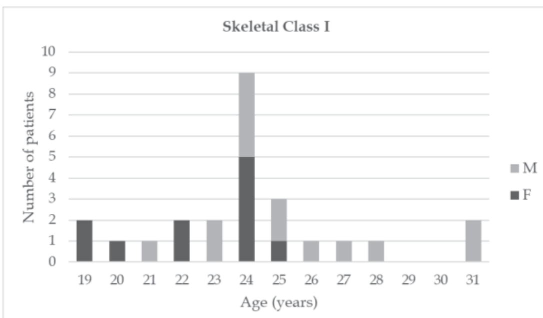

Figure 3. Sample distribution by age and gender in skeletal Class I group (M – males; F – females)

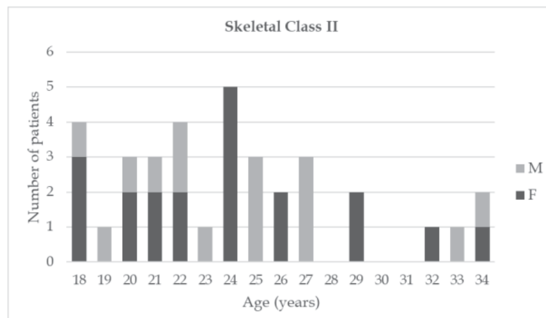

Figure 4. Sample distribution by age and gender in skeletal Class II group (M – males; F – females)

The descriptive statistics and the results of the independent-samples t-test are presented in Table 1. The independent-samples t-test was used to determine if there were differences in the pharyngeal width measurements between males and females belonging to the same group (skeletal Class I group and Class II group, respectively).

Table 1. Comparison of the pharyngeal width measurements between males and females belonging to the same group (Class I group and Class II group, respectively) and the results of the independent-samples t-test

Variables	Skeletal Class	Males				Females				t-test						
		N	Mean	SD	SEM	N	Mean	SD	SEM	*t*	df	*p*	Mean Diff.	SED	95% CI	
															Lower	Upper
PNSp-Ad (mm)	I	14	19.91	3.08	0.82	11	18.83	2.76	0.83	0.91	23.00	0.373	1.08	1.19	-1.38	3.54
	II	15	19.83	2.01	0.52	20	20.18	2.35	0.53	-0.47	33.00	0.643	-0.35	0.76	-1.89	1.18
UPAW (mm)	I	14	19.78	2.70	0.72	11	20.32	2.68	0.81	-0.50	23.00	0.623	-0.54	1.08	-2.78	1.70
	II	15	18.91	2.50	0.65	20	21.71	2.65	0.59	-3.17	33.00	0.003**	-2.81	0.88	-4.60	-1.01
MPAW (mm)	I	14	9.25	1.24	0.33	11	8.77	1.82	0.55	0.78	23.00	0.443	0.48	0.61	-0.79	1.74
	II	15	6.82	2.05	0.53	20	9.37	2.18	0.49	-3.51	33.00	0.001**	-2.55	0.73	-4.03	-1.07
LPAW (mm)	I	14	12.66	2.44	0.65	11	9.49	1.68	0.51	3.67	23.00	0.001**	3.17	0.86	1.38	4.95
	II	15	10.74	1.85	0.48	20	11.44	3.06	0.69	-0.79	33.00	0.438	-0.70	0.89	-2.52	1.12

N – sample size; SD – Std. Deviation; SEM - Std. Error Mean; df – degrees of freedom; Mean Diff. – Mean Difference; SED - Std. Error Difference; 95% CI – 95% Confidence Interval of the Difference; **$p < 0.005$.

The mean values of UPAW and MPAW in the skeletal Class II male subgroup were significantly lower than the mean values in the female subgroup ($p = 0.003$ and $p = 0.001$, respectively).

The mean values of LPAW in the skeletal Class I male subgroup were significantly higher than the mean values in the female subgroup ($p = 0.001$).

Table 2 shows the differences between the pharyngeal width measurements for the male subgroups belonging to different skeletal groups (Class I vs Class II) and the female subgroups belonging to different skeletal groups (Class I vs Class II).

Table 2. Comparison of the measured variables between males belonging to different skeletal groups and females belonging to different skeletal groups and the results of the independent-samples t-test

Variables	Gender (Class I vs Class II)	*t*	df	*p*	Mean Diff.	SED	95% CI	
							Lower	Upper
PNSp-Ad (mm)	M	0.09	27.00	0.930	0.08	0.96	-1.88	2.05
	F	-1.44	29.00	0.162	-1.35	0.94	-3.27	0.57
UPAW (mm)	M	0.90	27.00	0.374	0.87	0.97	-1.11	2.86
	F	-1.39	29.00	0.174	-1.39	1.00	-3.43	0.65
MPAW (mm)	M	3.82	27.00	0.001**	2.42	0.64	1.12	3.73
	F	-0.78	29.00	0.441	-0.60	0.77	-2.19	0.98
LPAW (mm)	M	2.40	27.00	0.023*	1.92	0.80	0.28	3.56
	F	-1.94	29.00	0.062	-1.94	1.00	-3.99	0.10

M – males; F – females; df – degrees of freedom; Mean Diff. – Mean Difference; SED - Std. Error Difference; 95% CI – 95% Confidence Interval of the Difference; *p < 0.05; **p < 0.005.

The mean values of MPAW and LPAW in the skeletal Class I male subgroup were significantly higher than the mean values in skeletal Class II male subgroup (p = 0.001 and p = 0.023, respectively).

There were no statistically significant differences between the patients (males and females overall) belonging to skeletal Class I group and the patients (males and females overall) belonging to skeletal Class II group (Table 3).

Table 3. Overall comparison of the measured variables between all the patients in skeletal Class I group and all the patients in skeletal Class II group and the results of the independent-samples t-test. A Welch t-test was used to analyse the variables PNSp-Ad and MPAW

Variables	Skeletal Class I				Skeletal Class II				t-test						
	N	Mean	SD	SEM	N	Mean	SD	SEM	*t*	df	*p*	Mean Diff.	SED	95% CI	
														Lower	Upper
PNSp-Ad (mm)	25	19.44	2.94	0.59	35	20.03	2.19	0.37	-0.85	42.11	0.398	-0.59	0.69	-1.99	0.81
UPAW (mm)	25	20.02	2.65	0.53	35	20.51	2.91	0.49	-0.67	58.00	0.505	-0.49	0.74	-1.96	0.98
MPAW (mm)	25	9.04	1.51	0.30	35	8.28	2.45	0.41	1.48	56.91	0.146	0.76	0.51	-0.27	1.78
LPAW (mm)	25	11.27	2.64	0.53	35	11.14	2.60	0.44	0.19	58.00	0.852	0.13	0.69	-1.24	1.50

N – sample size; SD – Std. Deviation; SEM - Std. Error Mean; df – degrees of freedom; Mean Diff. – Mean Difference; SED - Std. Error Difference; 95% CI – 95% Confidence Interval of the Difference.

DISCUSSIONS

In the literature, there are several different approaches of assessing the upper airway morphology and dimensions. There are studies using either 2D or 3D imaging techniques, with a variety of proposed landmarks and reference planes, which creates some difficulty in properly comparing the reported findings. Discrepancies between sample sizes and ethnic groups are other potential sources of contradictory results.

Nasopharyngeal dimensions were examined in many studies, both in Class I and Class II malocclusion. In one of these studies, Kim, Hong, Hwang and Park reported that the nasopharyngeal region had a similar or a wider width in subjects with Class II malocclusion, while the oropharyngeal area was narrower [13].

Alves et al. found that Class II patients had a narrower pharyngeal width, especially in the oropharynx at the level of the mandible and at the tip of the uvula, and also in the nasopharyngeal region at the level of the hard palate [2].

In a study that analyzed both the sagittal and vertical skeletal patterns, de Freitas et al. found that the type of malocclusion did not influence the upper and the lower pharyngeal airway widths in Class I and Class II patients [14].

Similar results were found by Memon, Fida and Shaikh [15] who concluded that the type of sagittal malocclusion had no effect on the upper pharyngeal width. Chauhan, Autar, Pradham and Yadav [16], found no significant differences in the measured pharyngeal anteroposterior dimensions between Class I and Class II Division I patients.

When we analyzed the sagittal skeletal groups in our study, without considering the patients' gender, we found similar results, with no statistically significant differences between the skeletal Class I group and the skeletal Class II group. When we compared the data for possible sexual dimorphism, our findings revealed that the mean values of the upper and middle pharyngeal airway widths in the skeletal Class II male subgroup were significantly lower than the mean values in the female subgroup.

Regarding the lower pharyngeal airway width, Küçükkaraca et al. compared Class II Division 1 and Division 2 groups with Class I malocclusion; the authors reported that the lower airway in Class I malocclusion was narrower than in Class II [17].

In our study we found that the mean values of the lower pharyngeal airway width in the skeletal Class I male subgroup were significantly higher than the mean values when compared both to the Class I female subgroup and the skeletal Class II male subgroup.

The main limitation of 2D radiographic images is that they cannot offer any information about the volume of the upper respiratory tract, therefore we intend to extend our research in the future to include a larger sample size and CBCT scans in order to better characterize the morphology of the pharyngeal structures.

CONCLUSIONS

The mean values of UPAW and MPAW in the skeletal Class II male subgroup were significantly lower than the mean values in the female subgroup. The mean values of LPAW in the skeletal Class I male subgroup were significantly higher than the mean values in the female subgroup. The mean values of MPAW and LPAW in the skeletal Class I male subgroup were significantly higher than the mean values in skeletal Class II male subgroup. There were no statistically significant differences between the patients (males and females overall) belonging to skeletal Class I group and the patients (males and females overall) belonging to skeletal Class II group.

REFERENCES

1. Indriksone I, Jakobsone G. The upper airway dimensions in different sagittal craniofacial patterns: a systematic review. Stomatologija. 2014;16(3):109–17.
2. Alves M, Franzotti ES, Baratieri C, Nunes LKF, Nojima LI, Ruellas ACO. Evaluation of pharyngeal airway space amongst different skeletal patterns. Int J Oral Maxillofac Surg. 2012 Jul;41(7):814–9.
3. Grauer D, Cevidanes LSH, Styner MA, Ackerman JL, Proffit WR. Pharyngeal airway volume and shape from cone-beam computed tomography: relationship to facial morphology. Am J Orthod Dentofacial Orthop. 2009 Dec;136(6):805–14.
4. Oh KM, Hong JS, Kim YJ, Cevidanes LSH, Park YH. Three-dimensional analysis of pharyngeal airway form in children with anteroposterior facial patterns. Angle Orthod. 2011 Nov;81(6):1075–82.
5. Diwakar R, Kochhar AS, Gupta H, Kaur H, Sidhu MS, Skountrianos H, Singh G, Tepedino M. Effect of Craniofacial Morphology on Pharyngeal Airway Volume Measured Using Cone-Beam

Computed Tomography (CBCT)—A Retrospective Pilot Study. Int J Environ Res Public Health. 2021;18(9):5040.
6. Lopatienė K, Dabkutė A, Juškevičiūtė V. Vertical and sagittal morphology of the facial skeleton and the pharyngeal airway. Stomatologija. 2016;18(1):21–5.
7. Swathi K, Maragathavalli G. Cephalometric assessment of the width of pharyngeal airway space and correlation with skeletal malocclusion- A retrospective study. J Pharm Sci Res. 2019;11(6):2263–6.
8. Kaur S, Rai S, Kaur M. Comparison of reliability of lateral cephalogram and computed tomography for assessment of airway space. Niger J Clin Pract. 2014;17(5):629–36.
9. Ryu HH, Kim CH, Cheon SM, Bae WY, Kim SH, Koo SK, Kim MS, Kim BJ. The usefulness of cephalometric measurement as a diagnostic tool for obstructive sleep apnea syndrome: a retrospective study. Oral Surg Oral Med Oral Pathol Oral Radiol. 2015 Jan;119(1):20–31.
10. Nadja e Silva N, Lacerda RHW, Silva AWC, Ramos TB. Assessment of upper airways measurements in patients with mandibular skeletal Class II malocclusion. Dental Press J Orthod. 2015 Sep;20(5):86–93.
11. Silva VG, Pinheiro LAM, Silveira PL da, Duarte ASM, Faria AC, Carvalho EGB de, Zancanella E, Crespo AN. Correlation between cephalometric data and severity of sleep apnea. Braz J Otorhinolaryngol. 2014;80(3):191–5.
12. Borges P de TM, da Silva BB, Moita Neto JM, Borges NE de S, Li LM. Cephalometric and anthropometric data of obstructive apnea in different age groups. Braz J Otorhinolaryngol. 2015 Jan 1;81(1):79–84.
13. Kim YJ, Hong JS, Hwang YI, Park YH. Three-dimensional analysis of pharyngeal airway in preadolescent children with different anteroposterior skeletal patterns. Am J Orthod Dentofacial Orthop. 2010;137(3):306.e1-306.e11.
14. de Freitas MR, Alcazar NMPV, Janson G, de Freitas KMS, Henriques JFC. Upper and lower pharyngeal airways in subjects with Class I and Class II malocclusions and different growth patterns. Am J Orthod Dentofacial Orthop. 2006 Dec;130(6):742–5.
15. Memon S, Fida M, Shaikh A. Comparison of Different Craniofacial Patterns with Pharyngeal Widths. J Coll Physicians Surg Pakistan. 2012;22(5):302–6.
16. Chauhan A, Autar R, Pradhan KL, Yadav V. Comparison of pharyngeal airway dimension, tongue and hyoid bone position based on ANB angle. Natl J Maxillofac Surg. 2015;6(1):42.
17. Küçükkaraca E, Üçüncü N. Sınıf II Div 1 ve Sınıf II Div 2 Malokluzyonlu Bireylerde Havayolunun Değerlendirilmesi [Aiway Evaluation in Class II Div 1 and Class II Div 2 Malocclusion Individuals]. Turkiye Klin Orthod Top. 2019;5(3):23–8.