Journal of Clinical and Translational Research 2024; 10(1): 93-98

Journal of Clinical and Translational Research

Journal homepage: http://www.jctres.com/en/home

ORIGINAL ARTICLE

Three-dimensional analysis of pharyngeal airway volume in Class I, II, and III malocclusion

Arkia Mardany[1], Alireza Naeimi Jafari[1], Alireza Khoshdel[2], Farzaneh Momeni[3], Nikan Mardany[4], Abdolreza Jamilian[1,5]

[1]Department of Orthodontic, Islamic Azad University Tehran Medical Sciences, Tehran, Iran, [2]Department of Public Health, Islamic Azad University Tehran Medical Sciences, Tehran, Iran, [3]Department of Oral and Maxillofacial Radiology, Tehran University of Medical Science, Tehran, Iran, [4]Department of Periodontics, School of Dentistry, Kermanshah University of Medical Science, Kermanshah, Iran, [5]Department of Orthodontics, City of London Dental School, University of Bolton, London, UK

ARTICLE INFO

Article history:
Received: September 08, 2023
Accepted: November 04, 2023
Published online: February 8, 2024

Keywords:
Cone-beam computed tomography
Skeletal pattern
Pharyngeal airway volume

**Corresponding author:*
Abdolreza Jamilian
Module leader, City of London Dental School, University of Bolton, London, UK
Orthodontic Department, Islamic Azad University Tehran Medical Sciences, Tehran, Iran
Email: info@jamilian.net

ABSTRACT

Aim: This study aimed to evaluate pharyngeal airway dimensions using cone-beam computed tomography (CBCT) in patients with Class I, II, and III malocclusions and normal growth patterns.
Methods: All CBCT images were categorized into three groups: Class I ($0° < \text{ANB} < 4°$, -1 mm $<$ Wits < 0 mm), Class II (ANB $> 4°$, Wits > 0 mm), and Class III (ANB $< 0°$, Wits < -1 mm). CBCT images were obtained from individuals with normal growth patterns ($32 \pm 5° = \text{GN/GO} - \text{SN}$), where GN represents gonion, GN is gnathion, and SN equates to the sella-nasion distance. Measurements were taken for total pharyngeal volume, velopharyngeal volume, glossopharyngeal volume, and oropharyngeal volume, and the narrowest area of the airway was measured. ANOVA and Tukey's *post hoc* test were used to compare the airway dimensions among skeletal classes I, II, and III.
Results: The CBCT images were captured from 90 patients (45 males and 45 females) aged 17 to 39. The mean volume of the total pharyngeal airway, velopharyngeal, glossopharyngeal, and oropharyngeal and the most constricted area were significantly greater in patients with skeletal Class III malocclusion compared to patients with skeletal Class II malocclusion showing normal growth pattern. Total pharyngeal airway, velopharyngeal, and oropharyngeal volumes were lower in Class II patients compared to Class I and III patients with normal growth patterns. There was a significant difference in the pharyngeal space between males and females with Class II malocclusion. Pharyngeal space in female Class II malocclusion was higher than that in males. There was no difference regarding airway space between female and male patients with Class 1 malocclusion. Pharyngeal space between females and males with Class III malocclusion showed no difference.
Conclusion: Class III pharyngeal volumes were generally larger in Class I and II malocclusions. Sex differences in the volumes of various pharyngeal spaces were only present in the case of Class II malocclusions.
Relevance for Patients: Class II pharyngeal volumes were generally smaller in Class I and III malocclusions.

1. Introduction

Since the 19th century, there has been a significant focus on investigating the connection between craniofacial morphology and respiratory function [1]. Numerous studies reviewed in the literature have suggested that the transition from two-dimensional (2D) radiography to three-dimensional (3D) cone-beam computed tomography (CBCT) represents a dependable and consistent approach capable of substituting conventional radiography [2-5].

DOI: https://doi.org/10.36922/jctr.23.00110

Some studies supported the association between skeletal pattern and the airway, while others did not show such a relationship. A study by Jadhav *et al.* [6] demonstrated that there was no significant correlation between the total airway volume and three sagittal skeletal groups. Alhammadi *et al.* [7] reported that the volume of the palatopharyngeal and glossopharyngeal airways and the narrowest point of the palatopharyngeal airway were greater in Class II skeletal than in other skeletal groups. Alves *et al.* [8] found that the type of malocclusion did not influence the dimensions and volumes of the airway in most cases. On the other hand, Tseng *et al.* [9] showed that individuals with Class II skeletal malocclusion have smaller airway volumes than individuals with Class I and III malocclusion. In a study by Shokri *et al.* [10], it was shown that the volume and area of the airway were significantly greater in Class III patients than in Class I or II. Zeng *et al.* [11] demonstrated that the volume of the pharyngeal airway was significantly greater in Class III and Class I patients compared to Class II patients. Due to the significant discrepancies in the results among the studies mentioned above and the lack of research regarding different sagittal malocclusion with normal growth patterns in the Middle Eastern population, the necessity of conducting this research became evident. Therefore, this study aimed to measure the relationship between the airway volume and skeletal Class I, Class II, and Class III malocclusions with normal growth patterns in individuals aged 17 – 39 years using CBCT.

2. Patients and Methods

In this study, we conducted a comprehensive analysis of CBCT obtained from the Department of Oral and Maxillofacial Radiology archives at Tehran Medical Sciences, Islamic Azad University. The survey was conducted in accordance with the guidelines of the Declaration of Helsinki. All human research was conducted in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, revised in 2013. Ethical approval was obtained from the Islamic Azad University Local Research Ethics Committees (protocol identifier IR.IAU.DENTAL, REC; 1400.041).

In this cross-sectional analytical study, the 90 CBCT images were divided into three groups, with 30 patients in each class, namely Class I, II, and III malocclusions. These CBCT images were obtained using a Sirona Galileos Sirona Dentsply device in Germany; all images were prepared by the Scan-Fast protocol, with a scan time of 14 s, a field of view of 15 cm × 15 cm, 98 kV, and 3 mA. All CBCTs were performed when the patients assumed the standing position, and patients stood when looking at themselves in the mirror. All images were taken from CBCT scans where the teeth were in occlusion, and all cephalograms of CBCT scans are completely real because they were extracted from CBCT images captured using the Sirona Galileos device, Germany. The patients were divided into three groups: Class I, Class II, and Class III, based on the ANB angle and Wits appraisal. The SNA and SNB angles were measured using the following points: S (the center of the sella turcica), N (the intersection points of the nasion and the frontal bone in the sagittal view), A (the innermost point on the anterior contour of the maxilla below the maxillary plane), and B (the innermost point on the anterior mandibular shape above the pogonion). The Wits appraisal is the measured distance between A and B along the mid-sagittal reference line. GoGn-SN angle was measured between the line of the gonion (Go) and gnathion (Gn) and the sella-nasion (SN) line. All patients were middle easterners and had normal growth patterns.

All CBCT images were selected from patients with a mandibular plane angle of 32 ± 5 = GoGn-SN.

- Class I: 0° < ANB < 4°; −1 mm < Wits < 0 mm
- Class II: ANB > 4°; 0 mm < Wits
- Class III: ANB < 0°; Wits < −1 mm

Exclusion criteria of this study are as follows:

The patients who had no history of orthognathic surgery, nasal surgery, syndromes, trauma, or pathology in the airway and pharynx.

CBCT images that lacked diagnostic value.

CBCT images were converted to DICOM format and transferred to 3D Dolphin software (Management & Imaging Solutions, Chatsworth, CA, USA). The overall volume of the pharyngeal airway and the most constricted area (mm^2) were assessed and determined (Figures 1 and 2). The measurements were performed by two researchers, and the intraclass correlation coefficient (ICC) was calculated to determine the reliability of the two researchers. In this study, the ICC was above 80%, indicating the reliability of the two researchers.

The definitions used throughout this study are as follows:

2.1. Total pharyngeal airway volume (TP)

The upper bound of the pharyngeal airway passes through PNS and is parallel to the standard horizontal plane; the lower bound passes through C4 and is parallel to the standard horizontal plane.

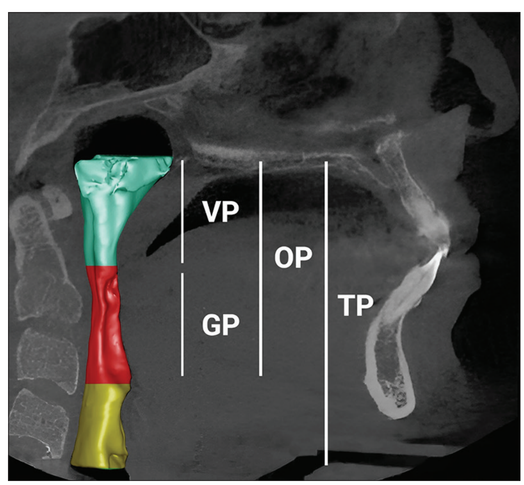

Figure 1. Three-dimensional upper airway model.
Abbreviations: VP: Velopharyngeal airway volume; GP: Glossopharyngeal airway volume; OP: Oropharyngeal volume; TP: Total pharyngeal airway volume.

DOI: https://doi.org/10.36922/jctr.23.00110

2.2. Velopharyngeal airway volume (VP)

The upper bound of the velopharyngeal airway passes through PNS and is parallel to the standard horizontal plane; the lower bound passes through the tip at the end of the soft palate and is parallel to the standard horizontal plane.

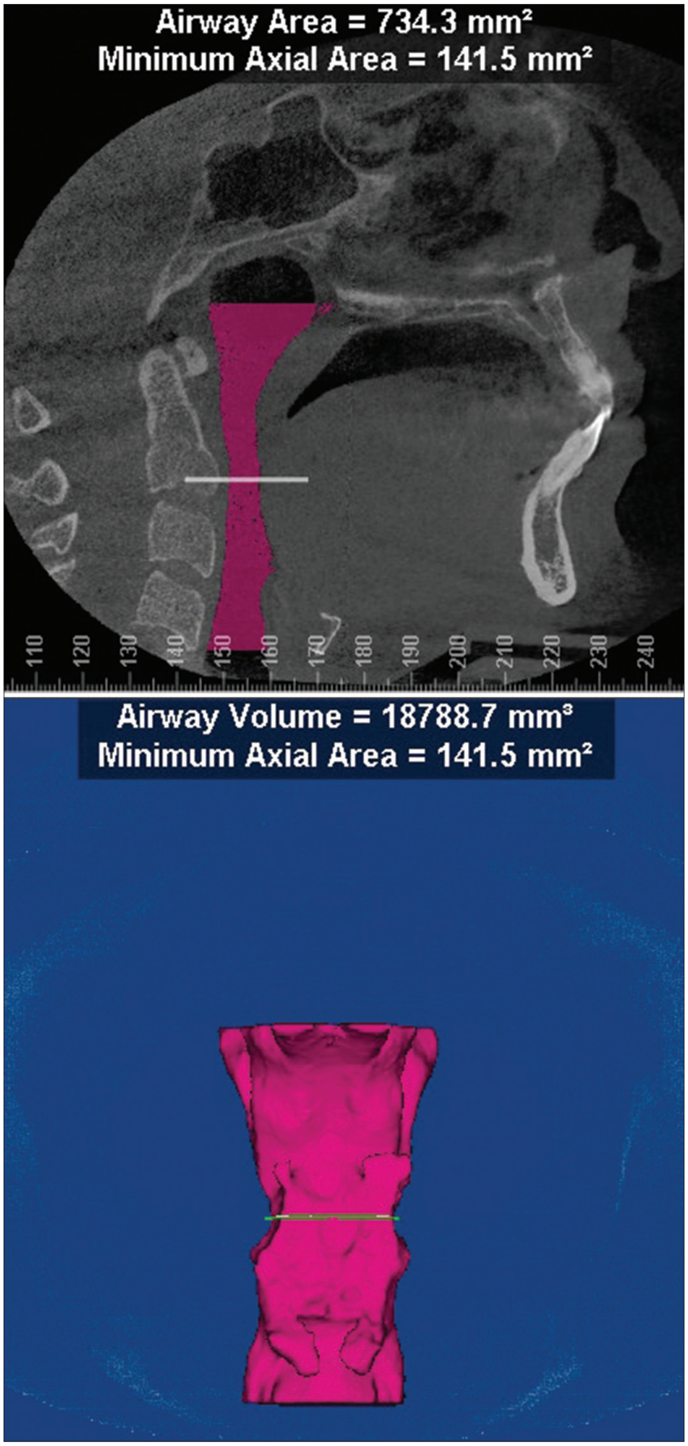

Figure 2. Three-dimensional upper airway model. Pink color refers to 3D pharyngeal volume.

2.3. Glossopharyngeal airway volume (GP)

The upper bound of the glossopharyngeal airway passes through the tip at the end of the soft palate and is parallel to the standard horizontal plane; the lower bound passes through the upper tip at the end of the epiglottis and is parallel to the standard horizontal plane.

2.4. Oropharyngeal airway volume (OP)

VP + GP, the velopharyngeal and glossopharyngeal airways are together known as the oropharyngeal airway.

2.5. Most constricted area

The smallest cross-sectional views of the upper respiratory tract of the image were measured.

The data were analyzed using SPSS software version 22.0 (IBM, Armonk, NY, USA). Analysis of variance (ANOVA) and Tukey's *post-hoc* correction were used to compare the dimensions of the airway among the skeletal malocclusion groups (Class I, II, and III). $P < 0.05$ was considered statistically significant.

3. Results

This study analyzed CBCT images of 90 patients (45 males and 45 females) aged 17 – 39 years. The three groups did not have any significant difference in terms of gender and age. All data were normally distributed. According to ANOVA results, there was a significant difference in the means of SNA, SNB, and ANB angles and Wits appraisal among the three malocclusion classes. However, the mean GoGn-SN angle did not show any significant difference among the three classes (Table 1).

The total pharyngeal airway volume was 19.483 ± 3.071, 16.091 ± 2.788, and 23.235 ± 5.684 mm^3 in Class I, II, and III malocclusions, respectively ($P < 0.001$). The volume of the total pharyngeal airway, velopharyngeal, glossopharyngeal, and oropharyngeal and the most constricted area in Class II malocclusion were less than Class I and III malocclusions ($P < 0.001$). The volume of velopharyngeal, glossopharyngeal, and oropharyngeal regions and the most constricted area were

Table 1. Comparison of cephalometric measurements according to the skeletal malocclusion

Variable	Type of malocclusion			*P*-value[1]
	Class I	Class II	Class III	
SNA[2]	81.8±1.9	81.5±2.0	79.8±2.2	0.005*
SNB[2]	79.3±2.1	76.1±2.8	81.5±2.2	<0.001*
ANB[2]	2.6±1.0	5.9±1.7	−1.8±1.4	<0.001 *
Wits	−3.0±0.3	4.0±2.3	−4.2±2.1	<0.001*
Sn-Go-Gn[2]	32.7±2.7	32.3±2.5	32.6±2.4	0.845

Data are expressed as mean±standard deviation.
[1]ANOVA; *statistically significant.
[2]S, the center of the sella turcica; N, the intersection points of the nasion and the frontal bone in the sagittal view; A, the innermost point on the anterior contour of the maxilla below the maxillary plane; and B, the innermost point on the anterior mandibular shape above the pogonion

DOI: https://doi.org/10.36922/jctr.23.00110

higher in Class III malocclusion compared to Class I and II malocclusions ($P < 0.001$; Table 2).

A significant difference in volume was observed in all pharyngeal space pairs between the two malocclusions, except glossopharyngeal volume in Class I versus II and Class I versus III. Furthermore, there were no significant differences in the most constricted area between classes I and II and between classes I and III (Table 3).

The independent *t*-test showed that there was no significant difference in pharyngeal space between males and females in Class I and III malocclusion. However, in Class II malocclusion, there was a significant difference between females and males (Table 4).

4. Discussion

The respiratory tract has a crucial role in swallowing, breathing, and articulation [12,13]. Airway space also affects the body posture and head inclination [14,15]. The mean volume of the pharyngeal, velopharynx, oropharynx, and glossopharynx and the mean area of the narrowest region airway in patients with skeletal Class III malocclusion were significantly larger than in patients with skeletal Class I and II malocclusions. Class III patients have a more protruding mandible and the tongue is positioned more anteriorly. These anatomical features consequently widen the distance between the posterior pharyngeal wall and the dorsum of the tongue, creating a larger airway space in skeletal Class III malocclusion than in classes I and II [9].

Several studies have evaluated the relationship between skeletal pattern, craniofacial morphology, and pharyngeal airway volume

Table 2. Comparison of the total pharyngeal airway, velopharyngeal, glossopharyngeal, oropharyngeal, and most constricted area per skeletal malocclusion

Variable	Type of malocclusion			*P*-value[1]
	Class I	Class II	Class III	
Total pharyngeal airway volume (mm³)	19.483±3.071	16.091±2.788	23.235±5.684	0.001*
Velopharyngeal volume (mm³)	9.995±2.230	8.258±1.922	11.670±3.514	<0.001*
Glossopharyngeal volume (mm³)	3.050±1.225	2.298±1.207	3.735±1.771	0.001*
Oropharyngeal volume (mm³)	13.112±2324	10.556±2596	15.405±4.612	<0.001*
Most constricted area (mm²)	154±45	119±46	173±92	<0.001*

Data are expressed as mean±standard deviation.
[1]ANOVA; *statistically significant

Table 3. Comparison of airway measurements in pairs between two malocclusions

Variable	Pair comparison	Result of comparison	*P*-value[1]
Total pharyngeal airway volume (mm³)	I versus II	I>II	0.005*
	I versus III	III>I	0.002*
	II versus III	III>II	< 0.001*
Velopharyngeal volume (mm³)	I versus II	I>II	0.034*
	I versus III	III>I	0.043*
	II versus III	III>II	<0.001*
Glossopharyngeal volume (mm³)	I versus II	I>II	0.108
	I versus III	III>I	0.156
	II versus III	III>II	<0.001*
Oropharyngeal volume (mm³)	I versus II	I>II	0.011*
	I versus III	III>I	0.025*
	II versus III	III>II	<0.001*
Most constricted area (mm²)	I versus II	I>II	0.095
	I versus III	III>I	0.460
	II versus III	III>II	0.004*

[1]Tukey's *post-hoc* correction; *statistically significant

Table 4. Sex-based comparative analysis of the total pharyngeal airway, velopharyngeal, glossopharyngeal, oropharyngeal, and most constricted area according to the class of skeletal malocclusion.

Malocclusion class	Gender	Mean and standard deviation	*P*-value[1]
I			
Total pharyngeal airway volume (mm³)	Male	19.023±2.877	0.421
	Female	19.944±3.288	
Velopharyngeal volume (mm³)	Male	9.807±2.445	0.653
	Female	10.182±2.061	
Glossopharyngeal volume (mm³)	Male	3.029±1.415	0.928
	Female	3.071±1.051	
Oropharyngeal volume (mm³)	Male	13.024±2.563	0.839
	Female	13.201±2.146	
Most constricted area (mm²)	Male	148±54	0.533
	Female	159±34	
II			
Total pharyngeal airway volume (mm³)	Male	14.873±2.479	0.014*
	Female	17.309±2.603	
Velopharyngeal volume (mm³)	Male	7.379±1.790	0.01*
	Female	9.137±1.671	
Glossopharyngeal volume (mm³)	Male	1.584±554	0.001*
	Female	30.12±1.273	
Oropharyngeal volume (mm³)	Male	8.963±2.176	0.001*
	Female	12.149±1.947	
Most constricted area (mm²)	Male	100±38	0.021*
	Female	137±46	
III			
Total pharyngeal airway volume (mm³)	Male	23.462±5.695	0.831
	Female	23.008±5.863	
Velopharyngeal volume (mm³)	Male	11.570±3.380	0.880
	Female	11.770±3.760	
Glossopharyngeal volume (mm³)	Male	3.681±1.706	0.871
	Female	3.789±1.892	
Oropharyngeal volume (mm³)	Male	15.251±4.673	0.859
	Female	15.559±4.708	
Most constricted area (mm²)	Male	186±90	0.462
	Female	161±94	

[1]Independent *t*-test; *statistically significant

DOI: https://doi.org/10.36922/jctr.23.00110

using CBCT, and reported conflicting results. Elagib *et al.* [16] found that skeletal patterns affect airway volume. However, the authors reported that age and sex also significantly influence airway variables. The findings in the current study differ from the data by Elagib *et al.*, who reported a significant difference between Class I, II, and III malocclusions with respect to pharyngeal space. In the current study, the age of patients was from 17 to 39 years, while the patients' age in the study by Elagib *et al.* was from 12 to 19 years. Furthermore, the race of patients in both studies was different, and both sex and age significantly affect pharyngeal space.

Tseng *et al.* measured the differences in airway volume and the smallest cross-sectional area of the pharynx among 90 patients with three skeletal patterns using CBCT. The authors observed that the mean overall volume of the respiratory pharyngeal airway, velopharynx, glossopharynx, oropharynx, and hypopharynx and the smallest cross-sectional area of the respiratory airway in Class III patients and Class I patients were significantly larger than in Class II patients. The study further revealed that the airway volume of the patients in skeletal Class II was only two-thirds of the airway volume of those in skeletal Class III, which is comparable to our study.

Opdebeeck *et al.* [17] reported that patients with a vertical growth pattern have a smaller airway space than those with a horizontal growth patterns. The difference between the findings of Opdebeeck *et al.* and current study is due to the growth pattern, which was normal in our study. It appears that the growth pattern affects the dimensions of the pharyngeal space.

Di Carlo *et al.* [18] evaluated the airway space of 90 young adult patients with Class I, II, and III malocclusions. They found no statistical difference between airway dimension and sagittal malocclusion. In contrast to our study, the CBCTs were acquired in supine position, where the patients were lying in a bed with their head fitted in a molded pillow. Moreover, Di Carlo *et al.* selected the CBCT images according to the following criteria: Class I ($0.5° < ANB < 4.5°$), Class II ($ANB > 4.5°$), and Class III ($ANB < 0.5°$). Future studies should attempt to evaluate the area of nasal vestibules, which is a restricting factor in nasal airflow. It is also recommended that the position of the hyoid bone be assessed about its muscular attachment.

One of the limitations of this study was that CBCT scans of patients with horizontal or vertical growth patterns were not included due to the insufficient number of such cases. It is expected that in future studies, airway dimensions will be evaluated in patients with Class I, II, and III malocclusions, including vertical, normal, and horizontal growth patterns, and the volume of the nasopharynx will also be measured.

5. Conclusions

The mean volume of the total pharyngeal airway, velopharyngeal, glossopharyngeal, and oropharyngeal and the most constricted areas were significantly greater in patients with skeletal Class III malocclusion compared to patients with skeletal Class II malocclusion with normal growth pattern. Total pharyngeal airway, velopharyngeal, and oropharyngeal volumes were lower in Class II patients compared to Class I and III patients with normal growth patterns. There was a significant difference in pharyngeal space between males and females with Class II malocclusion. Pharyngeal space in females with Class II malocclusion was larger than that in their male counterparts. There was no difference in airway space between female and male patients with Class 1 malocclusion. Pharyngeal space between females and males showed no difference in Class III malocclusion.

Acknowledgments

None.

Funding

Not applicable.

Conflict of interest

The authors declare no conflicts of interest.

Ethics approval and consent to participate

Ethical approval was obtained from the Islamic Azad University Local Research Ethics Committees (protocol identifier IR.IAU. DENTAL, REC;1400.041). Informed consent was obtained from the patients.

Consent for publication

Informed consent for releasing the patients data and/or images in this paper was obtained.

Availability of data

Data are available from the corresponding author upon reasonable request.

References

[1] Celikoglu M, Bayram M, Sekerci AE, Buyuk SK, Toy E. Comparison of Pharyngeal Airway Volume among Different Vertical Skeletal Patterns: A Cone-beam Computed Tomography Study. Angle Orthod 2014;84:782-7. doi: 10.2319/101013-748.1

[2] Moshiri M, Scarfe WC, Hilgers ML, Scheetz JP, Silveira AM, Farman AG. Accuracy of Linear Measurements from Imaging Plate and Lateral Cephalometric Images Derived from Cone-beam Computed Tomography. Am J Orthod Dentofacial Orthop 2007;132:550-60. doi: 10.1016/j.ajodo.2006.09.046

[3] Cattaneo PM, Melsen B. The Use of Cone-beam Computed Tomography in an Orthodontic Department in between Research and Daily Clinic. World J Orthod 2008;9:269-82.

[4] Kumar V, Ludlow J, Soares Cevidanes LH, Mol A. *In Vivo* Comparison of Conventional and Cone Beam CT Synthesized Cephalograms. Angle Orthod 2008;78:873-9. doi: 10.2319/082907-399.1

[5] Zamora N, Llamas JM, Cibrian R, Gandia JL, Paredes V. Cephalometric Measurements from 3D Reconstructed Images Compared with Conventional 2D Images. Angle Orthod 2011;81:856-64.
doi: 10.2319/121210-717.1

[6] Jadhav M, Bhosale V, Patil A, Shinde S. Comparison of Volumetric Dimensions of Pharyngeal Airway for Different Dentofacial Skeletal Patterns Using Cone Beam Computed Tomography. Folia Med (Plovdiv) 2020;62:572-7.
doi: 10.3897/folmed.62.e48930

[7] Alhammadi MS, Almashraqi AA, Halboub E, Almahdi S, Jali T, Atafi A, *et al*. Pharyngeal Airway Spaces in Different Skeletal Malocclusions: A CBCT 3D Assessment. Cranio 2021;39:97-106.
doi: 10.1080/08869634.2019.1583301

[8] Alves PV, Zhao L, O'Gara M, Patel PK, Bolognese AM. Three-dimensional Cephalometric Study of Upper Airway Space in Skeletal Class II and III Healthy Patients. J Craniofac Surg 2008;19:1497-507.
doi: 10.1097/SCS.0b013e31818972ef

[9] Tseng YC, Tsai FC, Chou ST, Hsu CY, Cheng JH, Chen CM. Evaluation of Pharyngeal Airway Volume for Different Dentofacial Skeletal Patterns Using Cone-beam Computed Tomography. J Dent Sci 2021;16:51-7.
doi: 10.1016/j.jds.2020.07.015

[10] Shokri A, Miresmaeili A, Ahmadi A, Amini P, Falah-Kooshki S. Comparison of Pharyngeal Airway Volume in Different Skeletal Facial Patterns Using Cone Beam Computed Tomography. J Clin Exp Dent 2018;10:e1017-28.
doi: 10.4317/jced.55033

[11] Zheng ZH, Yamaguchi T, Kurihara A, Li HF, Maki K. Three-dimensional Evaluation of Upper Airway in Patients with Different Anteroposterior Skeletal Patterns. Orthod Craniofac Res 2014;17:38-48.
doi: 10.1111/ocr.12029

[12] Schwab RJ, Goldberg AN. Upper Airway Assessment: Radiographic and Other Imaging Techniques. Otolaryngol Clin North Am 1998;31:931-68.
doi: 10.1016/s0030-6665(05)70100-6

[13] Jakobsone G, Stenvik A, Espeland L. The Effect of Maxillary Advancement and Impaction on the Upper Airway after Bimaxillary Surgery to Correct Class III Malocclusion. Am J Orthod Dentofacial Orthop 2011;139:e369-76.
doi: 10.1016/j.ajodo.2010.07.022

[14] Muto T, Takeda S, Kanazawa M, Yamazaki A, Fujiwara Y, Mizoguchi I. The Effect of Head Posture on the Pharyngeal Airway Space (PAS). Int J Oral Maxillofac Surg 2002;31:579-83.
doi: 10.1054/ijom.2002.0279

[15] Miyamoto K, Ozbek MM, Lowe AA, Fleetham JA. Effect of Body Position on Tongue Posture in Awake Patients with Obstructive Sleep Apnoea. Thorax 1997;52:255-9.
doi: 10.1136/thx.52.3.255

[16] Elagib T, Kyung HM, Hung BQ, Hong M. Assessment of Pharyngeal Airway in Korean Adolescents According to Skeletal Pattern, Sex, and Cervical Vertebral Maturation: A Cross-sectional CBCT Study. Korean J Orthod 2022;52:345-53.
doi: 10.4041/kjod21.267

[17] Opdebeeck H, Bell WH, Eisenfeld J, Mishelevich D. Comparative Study between the SFS and LFS Rotation as a Possible Morphogenic Mechanism. Am J Orthod 1978;74:509-21.
doi: 10.1016/0002-9416(78)90026-x

[18] Di Carlo G, Polimeni A, Melsen B, Cattaneo PM. The Relationship between Upper Airways and Craniofacial Morphology Studied in 3D. A CBCT Study. Orthod Craniofac Res 2015;18:1-11.
doi: 10.1111/ocr.12053

Publisher's note

AccScience Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.