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A 3D-CBCT Volumetric Analysis of Cervical Vertebrae Angulation and Airway Dimensions

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ABSTRACT

Aim: To evaluate the relationship between airway dimensions and cervical vertebrae angulations in dental patients using three-dimensional cone beam computed tomography (3D-CBCT) technology.

Materials and Methods: Pre-treatment CBCT scans and cephalometric radiographs were measured for 59 patients (mean age 22±2.3yrs.) using the Dolphin3D software system (version 11.7; Dolphin Imaging & Management Solutions, Chatworth, CA) to record airway dimensions and cervical vertebral angulations. All CBCT images were acquired using the same standard protocol for collection using the iCAT CBCT Unit (Imaging Sciences International, Hatfield, PA): 13cm field of view, 0.4mm voxel size, 8.9sec scan time. Intraclass Correlations (ICC) were performed on duplicate measurements of 10 CBCT scans after a two-week interval to assess reliability. P-value and Pearson correlation coefficients were used to statistically assess the relationship between vertebral angulations and airway dimensions.

Results: ICC values from the reliability assessment were >0.90. Pearson correlation coefficients were categorized based on confidence level as follows: high (>0.75 or <-0.75), moderate (0.5 to 0.74 or -0.5 to -0.74), or weak (0.3 to 0.49 or -0.3 to -0.49). No high/moderate correlations were observed. Weak correlations (p<0.05) were observed between the nasopharyngeal volume and the soft tissue thickness at CV1(-0.47) and CV2(-0.34). A weak correlation was observed between the nasal cavity volume and S-N (+0.41) as well as ANS-PNS(+0.38). A weak correlation was observed between the total airway volume and the soft tissue thickness at CV2(-0.34).

Conclusion: The soft tissue thickness of the posterior wall of the airway at the level of cervical vertebrae-2 appears to have a weak, negative correlation with several upper airway parameters and total airway volume. Soft tissue thickness of the posterior pharyngeal wall is crucial for dental clinicians to analyze prior to some procedures such as orthognathic surgery and orthodontic treatment that involve growth modification and jaw positioning, as it may have an association with decreased airway volume.

Clinical Significance: The relationship between cervical vertebrae angulation, airway, and craniofacial morphology is a complex aspect of human anatomy. In dentistry, it is crucial that clinicians recognize the vital role cervical vertebrae angulation and airway interact in relation to craniofacial morphology. Knowledge of these interconnections will significantly inform treatment planning for multiple oral health conditions such as malocclusions, jaw discrepancies, and temporomandibular joint disorders.

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Keywords: Airway Dimensions, CBCT Analysis, Cervical Vertebrae Angulations, Craniofacial Morphology

Introduction

In dentistry, recognizing the structure and angulation of the cervical vertebrae is important for a number of reasons. The study and prediction of remaining growth potential through Cervical Vertebrae Maturation (CVM) analysis is essential for proper orthodontic diagnosis and treatment planning. The timing of orthodontic and surgical procedures depends heavily on this information, particularly when growth modification is being considered. Furthermore, a thorough understanding of the relationship between cervical vertebrae angulation, airway dimensions, and craniofacial morphology is essential for diagnosis and treatment of the orofacial morphological and functional anomalies as well as jaw discrepancies [1-3].

Head and neck posture is directly correlated with anatomical factors such as facial structures and the cranial base, upper airway space, dental occlusion, and the temporomandibular joint [3]. Radiographic studies involving assessment of the cervical vertebral column indicated that the horizontal and vertical dimensions of the First Cervical Vertebra (CV1) and atlas, for example, were associated with head posture, cranial base angulation, and mandibular shape and growth [4].

Changes in cervical alignment may contribute to variations in occlusion, temporomandibular joint function, and overall dental stability. Simultaneously, alterations in airway dimensions directly affects breathing patterns during sleep, potentially leading to conditions such as Obstructive Sleep Apnea (OSA), which can also have significant oral and dental health implications [5,6]. Reports on the cervical vertebral column area in patients with OSA indicated that patients with OSA demonstrate an extended head posture. An extended head posture is frequently associated with increased anterior facial height, reduced sagittal jaw dimensions, and a steeper inclination of the mandible [7,8]. Cephalometric studies have previously indicated that when the head is bent in relation to the cervical vertebrae, a shorter anterior facial height, larger sagittal jaw dimensions, and a less steep inclination of the mandible were observed [9,10].

A comprehensive knowledge of the association between cervical vertebrae angulation and airway dimensions is crucial for dental practitioners addressing problems related to malocclusion, bruxism, and orofacial pain. The management of such conditions ideally require multidimensional perspective and an integrated approach among several healthcare professionals from different specialities. The aim of the current study was to assess the relationship between airway dimensions and cervical vertebrae angulations in a cohort of adult dental patients using three-dimensional cone beam computed tomography (3D-CBCT) technology.

Methods

This retrospective cross-sectional study utilized pre-treatment CBCT scans and cephalometric radiographs of 59 male Caucasian subject (mean age 22±2.3yrs.) collected from the archive of the orthodontic clinic at Indiana University School of Dentistry. The study was approved by the Institutional Review Board at Indiana University Purdue University at Indianapolis (IRB # 1708600071). Measurements were done using the Dolphin3D software system (version 11.7; Dolphin Imaging & Management Solutions, Chatworth, CA) to record airway dimensions and vertebral angulations. CBCT images for subjects with previous orthodontic treatment, orthognathic surgery, craniofacial anomalies, pharyngeal and/or nasal disease, and subjects on medications that depress respiration have been excluded from the study. All CBCT images were acquired using the same standard protocol for collection using the iCAT CBCT Unit (Imaging Sciences International, Hatfield, PA). The scanning setting used in this study was 13cm field of view, 0.4mm voxel size, 8.9sec scan time. A 12-inch receptor field was applied to include the Cervical Vertebrae 4 (CV4) to the cranial base and the soft-tissue contours of the face.

The boundaries of each airway segment (oropharynx, nasal cavity, nasopharynx, and hypopharynx), as well as the prevertebral soft-tissue thicknesses, and cervical vertebrae parameters used in the study are described in Tables 1-2 and Figures 1-5.

Table 1: Definitions of Anatomical Regions Used in the Study

Anatomical Area	Anterior Boundary	Posterior Boundary	Superior Boundary	Inferior Boundary
Nasopharynx (mm^3)	S - PNS	S - tip of the odontoid process		PNS - tip of the odontoid process
Oropharynx (mm^3)	PNS - hyoid bone (hy)	tip of the odontoid process - C4ps	PNS - tip of the odontoid process	hy - C4ps
Hypopharynx (mm^3)	hyoid bone (hy) - Menton (Me)	C4ps - C4Pi	C4ps - hyoid bone (hy)	C4Pi - Menton (Me)
Nasal cavity (mm^3)	anterior nasal spine (ANS) - the tip of the nasal bone - Nasion (N)	Sella point (S) - posterior nasal spine (PNS)	Nasion (N) - Sella point (S)	anterior nasal spine (ANS) - posterior nasal spine (PNS)
Total Airway Volume (mm^3)	S - PNS - hyoid bone (hy) - Menton (Me)	S - tip of the odontoid process - C4pi		C4Pi - Menton (Me)

Table 2: Description of the 3D Measurements of the Craniofacial Complex Used in the Study

Parameter	Description
CV1 - AA (mm)	Thickness of the soft tissue of the posterior wall of the airway at the nasopharynx level from Atlas Vertebra to the posterior wall of the airway.
CV2ia (mm)	Thickness of the soft tissue of the posterior wall of the airway at the oropharynx level from the most inferior anterior point of CV2 to the posterior wall of the airway.
CV3sa (mm)	Thickness of the soft tissue of the posterior wall of the airway at the oropharynx level from the most superior anterior point of CV3 to the posterior wall of the airway.
CV3ia (mm)	Thickness of the soft tissue of the posterior wall of the airway at the oropharynx level from the most inferior anterior point of CV3 to the posterior wall of the airway.
CV4sa (mm)	Thickness of the soft tissue of the posterior wall of the airway at the oropharynx level from the most superior anterior point of CV4 to the posterior wall of the airway.
CV4ia (mm)	Thickness of the soft tissue of the posterior wall of the airway at the oropharynx level from the most inferior anterior point of CV4 to the posterior wall of the airway.
CVT - FH (°)	The inclination of the cervical column represented as the angle between the cervical vertebrae tangent (CVT), the line connects the most posterior and superior point on CV2 and the most posterior and superior point on CV4, and Ramus line (RL).

SNA (°)	The anteroposterior position of the maxilla relative to the cranial base.
SNB (°)	The anteroposterior position of the mandible relative to the cranial base.
ANB (°)	The relationship between the maxillary and mandibular skeletal bases to each other.
Angle of Convexity (°)	The angle of convexity (NA-APg) relates the protrusion of the maxilla to both the cranium and the chin.
S-N (mm)	Length of the anterior cranial base.
ANS-PNS (mm)	Length of the maxilla
TFH (mm)	Length of the anterior facial height
AA-PNS (mm)	Anteroposterior dimension of the upper pharyngeal space
CVT-SN (°)	Head position in relation to the cervical column represented by the angle between CVT and the anterior cranial base (SN) plane
CVT-RL (°)	Head position in relation to the cervical column represented by the angle between CVT and the ramus line (RL)
OPT-SN (°)	Head position in relation to the cervical column represented by the angle between OPT and the anterior cranial base (SN) plane
OPT-RL (°)	Head position in relation to the cervical column represented by the angle between OPT and the ramus line (RL)
OPT-CVT (°)	Inclination of the two cervical reference lines to each other (ie, the cervical curvature represented by the angle between OPT and CVT)

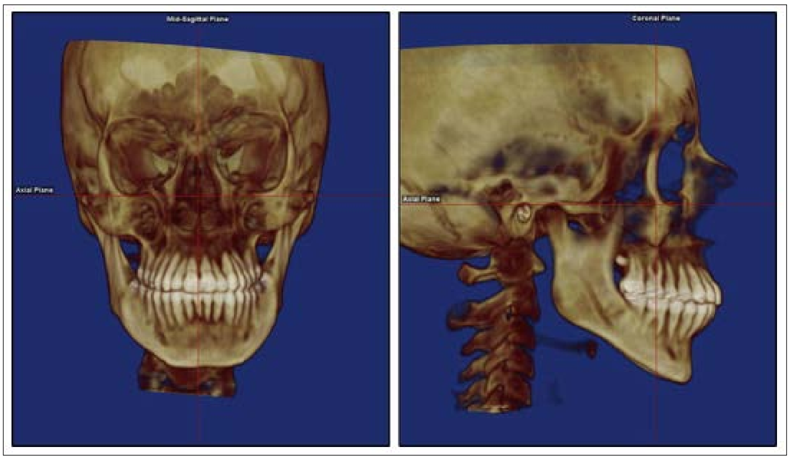

Figure 1: Image Orientation/Standardization (Frontal and Sagittal Views): The Midsagittal Plane was Adjusted on the Skeletal Midline of the Face, The Axial Plane was Adjusted to Show the Frankfort Horizontal Plane (Right Porion-Right Orbitale), and the Coronal Plane was Adjusted through the Furcation of the First Maxillary Molar.

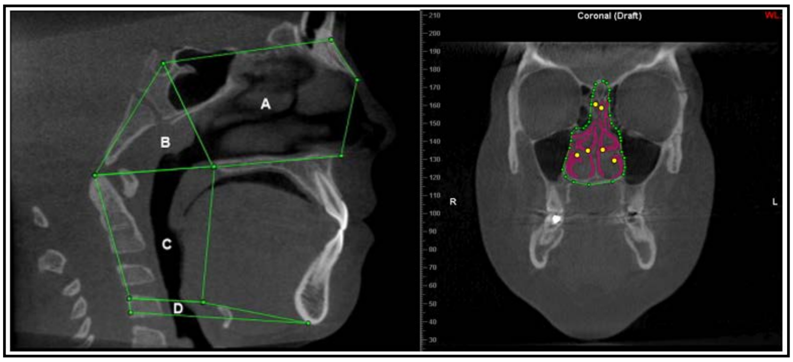

Figure 2: Airway Boundary Parameters: (Left) Sagittal View of the Boundaries of the Airway Divisions: A, Nasal Cavity; B, Nasopharynx; C, Oropharynx; and D, Hypopharynx. (Right) Coronal View of the Nasal Cavity Boundaries and Airway Space.

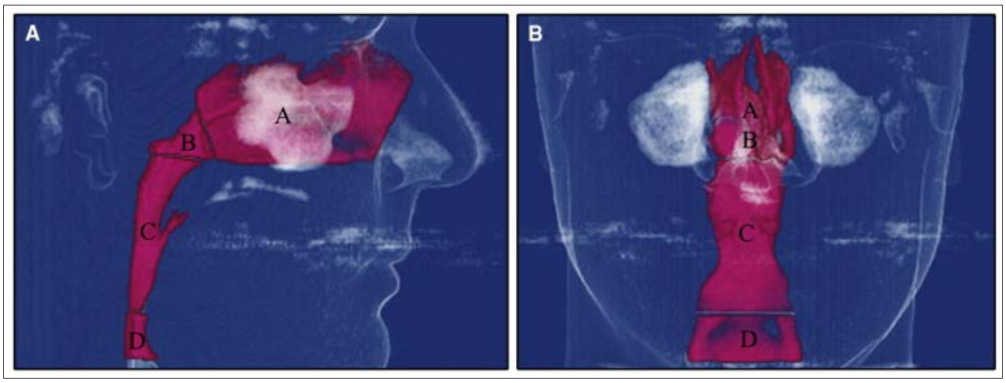

Figure 3: Airway Space Illumination and Volume Calculation: Three-Dimensional Rendering of the Boundaries of the Airway Divisions. (Left) Sagittal View of: A, Nasal Cavity; B, Nasopharynx; C, Oropharynx; D, Hypopharynx. (Right) Frontal View of: A and B, Nasal Cavity Overlaid on Nasopharynx; C, Oropharynx; and D, Hypopharynx. Airway Volumes Reported in mm3 Using Dolphin 3D Software System.

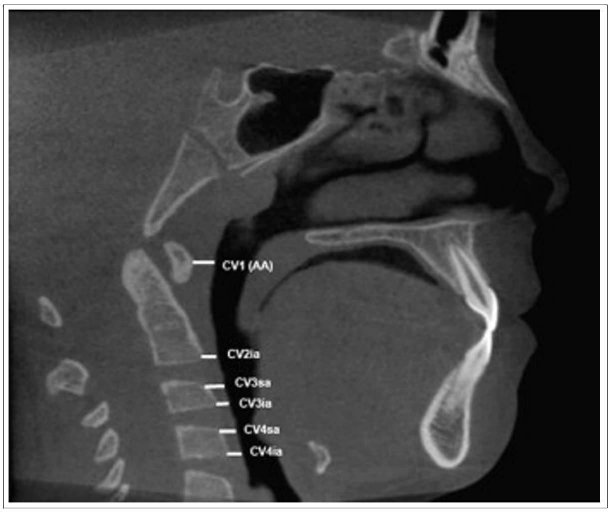

Figure 4: Soft Tissue Thickness Identification: Prevertebral Soft-Tissue Thicknesses Measured as Two-Dimensional, Horizontal Lines Drawn from the Edges of the Vertebrae to the Posterior Wall of the Pharynx, Calculated in mm^2

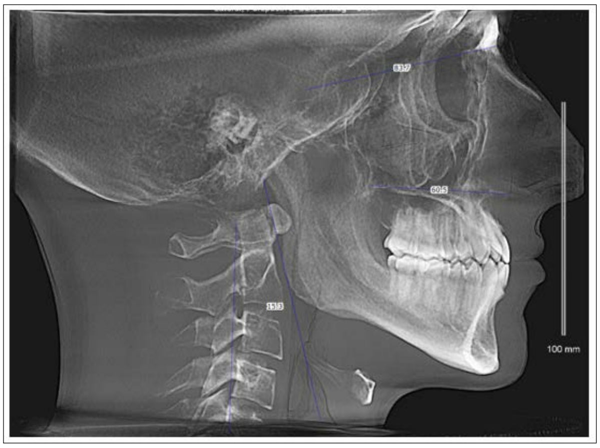

Figure 5: Cervical Vertebral Angulation and Cephalometric Parameter Identification: Cervical Vertebrae Tangent (CVT) on Posterior CV2 and CV4. Ramus Line (RL) Tangential to the Posterior Border of the Mandibular Ramus. Standard Cephalometric Parameters Pictured Above (S-N and ANS-PNS).

The sample size needed for conducting this study was calculated using the G*Power 3.1 software. A sample size of 59 achieved 95% power with α=0.05 and effect size 1.76. Intraclass Correlations (ICC) were performed on duplicate measurements of 10 CBCT scans after a two-week interval to assess reliability. P-value and Pearson correlation coefficients were used to statistically assess the relationship between vertebral angulations and airway dimensions. All statistical calculations were done using Microsoft Excel 2010 (Microsoft Corporation, NY, USA) and Statistical Package for the Social Sciences software (version 15; SPSS, Chicago, IL, USA).

Results

Before starting the data collection, the primary investigator (SR) completed reliability study including all measurements performed twice with two weeks interval in between. ICC were calculated to statistically analyse the intrarater reliability. ICC values were > 0.90 for all measurements.

Table 3: Reliability Study Results

Measurement	First, Mean (SE)	Second, Mean (SE)	Difference, Mean (SE)	P-Value	ICC
Nasopharynx Volume (mm^3)	9302.3 (1120.4)	9189.3 (1120.4)	113.0 (101.6)	0.29	1.00
Oropharynx Volume (mm^3)	24681.3 (3650.6)	24628.9 (3650.6)	52.4 (160.0)	0.75	1.00
Hypopharynx Volume (mm^3)	4444.8 (585.7)	4391.0 (585.7)	53.8 (72.8)	0.48	0.99
Nasal Cavity Volume (mm^3)	30150.7 (2511.4)	30174.0 (2511.4)	-23.4 (782.4)	0.98	0.96
Total Airway Volume (mm^3)	34686.7 (4683.6)	34463.4 (4683.6)	223.3 (300.4)	0.48	1.00
Minimum Axial Airway Area (mm2)	197.6 (30.3)	202.2 (30.3)	-4.6 (5.6)	0.44	0.98
Soft Tissue Thickness CV1 (mm)	3.8 (0.3)	3.7 (0.3)	0.1 (0.1)	0.28	0.95
Soft Tissue Thickness CV2 (mm)	4.4 (0.2)	4.4 (0.2)	0.0 (0.1)	0.91	0.92
Soft Tissue Thickness CV3 sa (mm)	5.6 (0.3)	5.5 (0.3)	0.1 (0.1)	0.50	0.94
Soft Tissue Thickness CV3 ia (mm)	4.6 (0.3)	4.6 (0.3)	0.0 (0.1)	0.68	0.95
Soft Tissue Thickness CV4 (mm)	5.2 (0.3)	5.3 (0.3)	-0.1 (0.1)	0.15	0.96
SNA (°)	82.0 (1.2)	82.0 (1.2)	0.0 (0.2)	0.81	0.99
SNB (°)	80.0 (0.8)	79.7 (0.8)	0.2 (0.1)	0.14	0.98
ANB (°)	2.0 (0.9)	2.2 (0.9)	-0.2 (0.1)	0.11	0.99
Angle of Convexity (°)	5.9 (1.1)	5.7 (1.1)	0.2 (0.2)	0.29	0.99
S-N (mm)	76.1 (1.4)	76.0 (1.4)	0.1 (0.2)	0.69	0.99
ANS-PNS (mm)	55.5 (1.4)	55.6 (1.4)	-0.1 (0.2)	0.64	0.99
TFH (mm)	131.4 (2.2)	131.4 (2.2)	0.0 (0.1)	0.76	1.00
AA-PNS (mm)	40.3 (0.8)	40.1 (0.8)	0.2 (0.2)	0.42	0.96
CVT-SN (°)	108.3 (1.3)	108.4 (1.3)	-0.1 (0.2)	0.68	0.99
CVT-RL (°)	19.8 (1.5)	19.8 (1.5)	0.0 (0.2)	0.81	0.99
OPT-SN (°)	102.2 (1.7)	102.2 (1.7)	0.0 (0.2)	0.89	0.99
OPT-RL (°)	13.8 (1.9)	13.7 (1.9)	0.0 (0.2)	0.87	1.00
OPT-CVT (°)	6.1 (0.8)	6.1 (0.8)	0.0 (0.2)	0.95	0.98

Pearson correlation coefficients relating cervical vertebrae position, airway volumes, and dentoskeletal landmarks were categorized based on confidence level as follows: 'high' (> 0.75 or < -0.75), 'moderate' (0.5 to 0.74 or -0.5 to -0.74), 'weak' (0.3 to 0.49 or -0.3 to -0.49), or 'none' (-0.29 to 0.29). No high/moderate correlations were observed between cervical vertebral angulations and airway dimensions. Weak correlations were observed between the following parameters ($p<0.05$): Nasopharynx Volume (mm3): weak correlations were observed between the volume of the nasopharynx and the thickness of the soft tissue at the level of CV1 (-0.47) and CV2 (-0.34). Oropharynx Volume (mm3): A weak correlation (+0.32) was observed between the volume of the oropharynx and the total facial height (TFH: distance in mm from points nasion-menton). Nasal Cavity Volume (mm3): weak correlation (+0.41) was observed between the volume of the nasal cavity and the S-N (sella-nasion). A weak correlation (+0.38) was similarly observed between the volume of the nasal cavity and the ANS-PNS (anterior nasal spine-posterior nasal spine). Total Airway Volume (mm3): weak correlation (-0.34) was observed between the total airway volume and the thickness of the soft tissue at the level of CV2. Soft Tissue Thickness (mm) at CV3ia: weak correlations were observed between the thickness of the soft tissue at the level of CV3 and the following cervical vertebrae angulations: CVT-RL (+0.33), OPT-SN (+0.33), OPT-RL (+0.38).

Table 4: CBCT/Cephalometric Data

Parameter	Mean (SD)	95% CI for Mean
Nasopharynx Volume (mm^3)	7851 (2614)	7169, 8532
Oropharynx Volume (mm^3)	23117 (8492)	20904, 25330
Hypopharynx Volume (mm^3)	4405 (1585)	3993, 4818
Nasal Cavity Volume (mm^3)	30540 (8260)	28387, 32692
Total Airway Volume (mm^3)	31217 (10372)	28514, 33920
Minimum Axial Airway Area (mm^2)	152 (82)	131, 174
Soft Tissue Thickness CV1 (mm)	5.09 (2.17)	4.52, 5.65
Soft Tissue Thickness CV2 (mm)	4.81 (0.80)	4.60, 5.02
Soft Tissue Thickness CV3 sa (mm)	5.48 (0.95)	5.23, 5.73
Soft Tissue Thickness CV3 ia (mm)	4.82 (1.10)	4.53, 5.10
Soft Tissue Thickness CV4 sa (mm)	5.44 (1.38)	5.08, 5.80
Soft Tissue Thickness CV4 ia (mm)	5.46 (1.38)	5.16, 5.80
SNA (°)	82.43 (4.01)	81.39, 83.47
SNB (°)	80.49 (3.71)	79.52, 81.46
ANB (°)	1.94 (2.26)	1.35, 2.53
Angle of Convexity (°)	3.81 (4.36)	2.67, 4.94
S-N (mm)	77.37 (4.68)	76.15, 78.59
ANS-PNS (mm)	55.24 (4.18)	54.15, 56.33
TFH (mm)	130.24 (8.23)	128.10, 132.39
AA-PNS (mm)	40.78 (4.40)	39.63, 41.92
CVT-SN (°)	105.37 (6.20)	103.76, 106.99
CVT-RL (°)	18.78 (6.08)	17.20, 20.37
OPT-SN (°)	99.73 (5.73)	98.23, 101.22
OPT-RL (°)	12.92 (6.30)	11.27, 14.56
OPT-CVT (°)	5.67 (2.95)	4.90, 6.44

Table 5: CBCT/Cephalometric Correlations

Parameters		Correlation	p-value
Nasopharynx Volume (mm^3)	Minimum Axial Airway Area (mm^2)	Tr5+0.29	0.0260
Nasopharynx Volume (mm^3)	Soft Tissue Thickness CV1 (mm)	-0.47	0.0002
Nasopharynx Volume (mm^3)	Soft Tissue Thickness CV2 (mm)	-0.34	0.0072
Oropharynx Volume (mm^3)	TFH (mm)	+0.32	0.0127
Oropharynx Volume (mm^3)	Soft Tissue Thickness CV2 (mm)	-0.30	0.0214
Hypopharynx Volume (mm^3)	ANS-PNS (mm)	+0.28	0.0322
Hypopharynx Volume (mm^3)	TFH (mm)	+0.28	0.0308
Nasal Cavity Volume (mm^3)	S-N (mm)	+0.41	0.0011
Nasal Cavity Volume (mm^3)	ANS-PNS (mm)	+0.38	0.0029
Nasal Cavity Volume (mm^3)	CVT-RL (°)	-0.29	0.0263
Nasal Cavity Volume (mm^3)	OPT-RL (°)	-0.26	0.0485
Total Airway Volume (mm^3)	TFH (mm)	+0.28	0.0342
Soft Tissue Thickness CV1 (mm)	AA-PNS (mm)	+0.34	0.0082
Soft Tissue Thickness CV2 (mm)	Angle of Convexity (°)	-0.37	0.0036
Soft Tissue Thickness CV2 (mm)	TFH (mm)	0.26	0.0448
Soft Tissue Thickness CV3ia (mm)	Angle of Convexity (°)	-0.28	0.0303
Soft Tissue Thickness CV3ia (mm)	TFH (mm)	+0.31	0.0173
Soft Tissue Thickness CV3ia (mm)	CVT-SN (°)	+0.27	0.0352

Soft Tissue Thickness CV3ia (mm)	CVT-RL (°)	+0.33	0.0103
Soft Tissue Thickness CV3ia (mm)	OPT-SN (°)	+0.33	0.0099
Soft Tissue Thickness CV3ia (mm)	OPT-RL (°)	+0.38	0.0024
Soft Tissue Thickness CV4ia (mm)	TFH (mm)	+0.27	0.0376
Soft Tissue Thickness CV4ia (mm)	OPT-RL (°)	+0.26	0.0452

Discussion

The relationship between cervical vertebrae angulation, airway, and craniofacial morphology is a complex aspect of human anatomy. Cervical vertebrae, forming the neck's spine, contribute to head posture and movement. Any abnormalities in angulation can influence the overall body posture as well as the head and neck position and function. This will, subsequently, impact the dimensions and patency of the airway. Craniofacial morphology and development are influenced by genetic and environmental factors, including functional demands like growth and breathing. Studies suggest that alterations in cervical spine alignment, such as forward head posture, may influence the positioning and function of the jaws and airway, potentially contributing to conditions such as OSA. Interdisciplinary collaboration among orthopaedic, dental, and sleep medicine professionals is crucial for comprehensively addressing these complex interactions, considering individual variations and the multifactorial nature of these relationships in clinical assessments and treatment planning [9,11-13].

In dentistry, it is crucial that clinicians recognise the vital role cervical vertebrae angulation and airway interact in relation to craniofacial morphology and development. Knowledge of these interconnections is clinically relevant and might significantly inform treatment planning for multiple oral health conditions such as malocclusions, jaw discrepancies, and temporomandibular joint disorders. More importantly, dental clinicians with insights into cervical vertebra angulation and airway dynamics may contribute to identifying potential risk factors for systemic conditions like breathing disorders and OSA. A comprehensive understanding of these relationships allows dentists to adopt a holistic approach to oral health, considering not only the dental and craniofacial aspects but also the broader musculoskeletal and respiratory dimensions, ultimately contributing to more effective and patient-centred dental care [14,15]. The aim of the current study was to assess the correlation between airway dimensions and cervical vertebrae angulations in a cohort of adult dental patients.

The oropharyngeal region, which includes the soft palate, the dorsum of the tongue, and the posterior pharyngeal wall, is typically where adults experience airway obstruction during apnoeic episodes of OSA and other conditions associated with shortness of breath. Several reports indicated reduced antero-posterior dimensions of the pharyngeal airway in the awake prone posture in adults, together with increased length and thickness of the soft palate, larger tongue and a lower position of the hyoid bone [6]. Most of the earlier studies on the size of the airway and its craniofacial correlations have been based on cephalometric analysis using two-dimensional imaging modalities which makes it difficult to detect airway abnormalities from different perspectives. In the current study, 3D CBCT imaging technology was used for more comprehensive and detailed assessment. Nowadays, dental practitioners use CBCT more frequently. It allows clearer images and facilitates accurate upper airway assessment especially for screening abnormalities. Additionally, it aids in locating areas where airway restriction is greatest laterally and anteroposteriorly. Sagittal, coronal, and transverse planes are three anatomical planes on which the total volume and area of the airways can be calculated using CBCT.

It is widely accepted that obstruction of the upper airway triggers a physiological response in the form of an extension of the head relative to the cervical column [16]. The current study findings indicated weak correlations between the nasopharyngeal volume and the soft tissue thickness at CV1 and CV2 as well a weak correlation between the nasal cavity volume and S-N and ANS-PNS in a sample of adult dental patients with normal breathing patterns. An earlier study evaluating the natural head posture of OSA patients in the standing position found the average craniocervical angulation to be extremely large, more than two SD above the mean for reference samples. Investigators claimed that this might mainly be mediated by the forward inclination of the cervical column [17]. This was confirmed by a later study reporting similar but smaller changes in head posture observed in patient groups with different types of obstruction of the upper airway [18]. In the current study, correlations were found between the soft tissue thickness of the airway at the level of the oropharynx but this correlation was considered weak.

The total airway volume represents the area that includes the nasopharynx, oropharynx, and hypopharynx. Several factors might impact the size of the airway passage. These factors include abnormalities in the location or size of the uvula, tongue, and epiglottis. In addition, the soft tissue thickness of the airway has been found to be directly correlated with the total airway volume [19]. In the current study, a weak correlation was observed between the total airway volume and the soft tissue thickness at CV2. The weak correlation could be related to the selected sample as none of the subjects included in this study reported abnormal breathing patterns or airway disorders. Limitation of the study include the retrospective design and the very limited number of previous relevant research. In order to proclaim possible generalization of the results, future studies must address these two major limitations.

Conclusion

The soft tissue thickness of the posterior wall of the airway at the level of cervical vertebrae-2 appears to have a weak, negative correlation with several upper airway parameters and total airway volume. Soft tissue thickness of the posterior pharyngeal wall is crucial for dental clinicians to analyze prior to some procedures such as orthognathic surgery and orthodontic treatment that involve growth modification and jaw positioning, as it may have an association with decreased airway volume.

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