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ORIGINAL ARTICLE

Observational Study

Contents

ABOUT COVER

Miguel A De Gregorio, BM BCh, MD, PhD, Chief Doctor, Professor, Research Scientist, Department of Radiology Medicine Faculty, University of Zaragoza, Zaragoza 50009, Spain. mgregori@unizar.es

AIMS AND SCOPE

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RESPONSIBLE EDITORS FOR THIS ISSUE

Observational Study

Cone beam computed tomographic evaluation of pharyngeal airway in North Indian children with different skeletal patterns

Anuraj Singh Kochhar, Maninder Singh Sidhu, Ritasha Bhasin, Gulsheen Kaur Kochhar, Himanshu Dadlani, Jagpreet Sandhu, Bobby Virk

ORCID number: Anuraj Singh Kochhar 0000-0001-6611-6143; Maninder Singh Sidhu 0000-0002-2481-7109; Ritasha Bhasin 0000-0002-6198-7756; Gulsheen Kaur Kochhar 0000-0001-5881-3512; Himanshu Dadlani 0000-0002-7354-1962; Jagpreet Sandhu 0000-0001-5449-0306; Bobby Virk 0000-0002-4063-7108.

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Anuraj Singh Kochhar, Former Orthodontist, Max Hospital, Gurgaon 122001, India

Maninder Singh Sidhu, Department of Orthodontics, Faculty of Dental Sciences, SGT University, Gurugram 122001, India

Ritasha Bhasin, Faculty of Dentistry, University of Toronto, Toronto M5G 1G6, Canada

Gulsheen Kaur Kochhar, Department of Pediatric and Preventive Dentistry, National Dental College and Hospital, Derabassi 140507, Punjab, India

Himanshu Dadlani, Department of Periodontology, Kalka Dental College, Uttar Pradesh 210507, India

Himanshu Dadlani, Senior Consultant, Department of Dental Surgery, Max Hospital, Gurgaon 122001, India

Jagpreet Sandhu, Formerly at Department of Orthodontics, Genesis Institute of Dental Sciences, Punjab 152001, India

Bobby Virk, Chief Orthodontist, Smile With Braces, Puyallup, WA 98371, United States

Corresponding author: Himanshu Dadlani, MDS, Professor, Department of Periodontology, Kalka Dental College, Meerut, Uttar Pradesh 210507, India. himdent@hotmail.com

Abstract

BACKGROUND

In growing patients with skeletal discrepancies, early assessment of functional factors can be vital for the restoration of normal craniofacial growth.

AIM

To compare airway volumes in patients with mandibular retrognathism with the normal anteroposterior skeletal relationship, thereby assessing the association between cephalometric variables and airway morphology.

METHODS

Cone-beam computed tomography volume scans, and lateral cephalograms, 3-dimensional airway volume and cross-sectional areas of 120 healthy children (54 boys and 66 girls mean age 15.19 ± 1.28) which were done for orthodontic

assessment were evaluated. The subjects were divided into 2 groups based on the angle formed between point A, Nasion and point B (ANB) values and cephalometric variables (such as anterior and posterior facial height, gonial angle *etc.*) airway volumes, and cross-sectional measurements were compared using independent *t* tests. Pearson's correlation coefficient test was used to detect any relationship of different parts of the airway and between airway volume and 2-dimensional cephalometric variables.

RESULTS

Means and standard deviations for cephalometric, cross-sectional, and volumetric variables were compared. ANB, mandibular body length and facial convexity were statistically highly significant ($P < 0.01$) whereas condylion to point A, nasal airway and total airway volume ($P < 0.05$) were statistically significant. The nasal airway volume and the superior pharyngeal airway volume had a positive correlation ($P < 0.01$), nasal airway was correlated to middle ($P < 0.05$) and total airway superior had a relation with middle ($P < 0.05$), inferior and total airway ($P < 0.05$), middle was related to all other airways; inferior was also related to all the airways except nasal. Lateral cephalometric values were positively correlated with the airway volume with Frankfurt Mandibular Plane Angle and facial convexity showed significant correlations with total airway volume ($P < 0.05$). Additionally, ANB angle was significantly correlated with total airway volume and superior airway ($P < 0.05$).

CONCLUSION

The mean total airway volume in patients with retrognathic mandible was significantly smaller than that of patients with a normal mandible.

Key Words: Pharyngeal airway; Cone beam computed tomography; Skeletal pattern; Malocclusion; Retrognathic; Airway volume

Core Tip: With the advent of cone beam computed tomography, analysis of airway has become possible. Patients who present with retrognathic jaw or anterior-posterior skeletal discrepancy have been contemplated to have reduced pharyngeal airway. When comparing the airway volumes of 120 healthy individuals with mandibular retrognathism and normal anteroposterior skeletal relationship, the mean total airway volume of patients with the angle formed between point A, Nasion and point B (ANB) more than 4 was significantly smaller than that of patients with ANB less than 4. The sub-volumes in the pharyngeal airway showed a positive correlation with each other. Frankfurt Mandibular Plane Angle and facial convexity and mandibular body length also had a significant interrelationship with total volume of airway.

INTRODUCTION

Respiratory function plays a substantial role in orthodontic diagnosis and treatment planning. An association between the respiratory mode and facial morphology has been observed in various studies utilizing cephalograms[1]. Furthermore, a link between Class II Division 1 malocclusion and upper pharyngeal airway obstruction as well as mouth breathing, was demonstrated by Angle[2] in 1907. Various authors have presented characteristics related to obstructed breathing[1]. Primary clinical features of respiratory obstruction syndrome have been identified by Ricketts[3] as tonsil and adenoid enlargement, narrow nostrils, open bite, cross bite, and tongue thrusting.

The role of the upper anatomy in the craniofacial complex development is usually considered substantial[4]. Impaired breathing can be a result of narrow pharyngeal airway, which can further lead to diminished levels of growth hormone in growing children or obstructive sleep apnea in mature individuals. Diminished airway associated with obstructive sleep apnea tends to be typical in patients with Angle class II malocclusion, displaying retrognathic mandible and sagittal discrepancy[5,6].

Early diagnosis and evaluation of the functional factors in growing children with skeletal discrepancy and features of adenoid hypertrophy (adenoid faces) might be pivotal to restore proper craniofacial growth and treatment outcome stability. Pharyngeal airway measurements have usually been conducted by landmark identification followed by measurements of different lengths and areas in the pharyngeal region[7-9].

Although there is an avalanche of studies regarding airway morphology and its effects on craniofacial growth, most studies have used 2-dimensional (2D) techniques, frontal or lateral cephalograms, with inadequate assessment of length and areas. A technique for 3-dimensional (3D) visualization, utilized frequently is computed tomography[10]. However, a huge impediment to its use is the large radiation dose[11]. The radiation dose can be minimized to one-fifth, while not compromising on quality, with modern cone beam computed tomography (CBCT), due to which it is becoming increasingly popular[12].

Volumetric measurements of the pharyngeal airway space (PAS) and, narrowing or obstruction can be localized utilizing CBCT[13]. As narrowing or obstruction of the pharyngeal airway can be present in patients with altered maxillo-mandibular relationship and can be associated with sleep, as well as Obstructive Sleep Apnoea Syndrome, this analysis can be beneficial in the orthodontic diagnosis and planning orthognathic surgery[14]. Therefore, the aim of the present study was to compare the pharyngeal airway volumes in children with varying anteroposterior maxillo-mandibular relationships (ANB angles that is the angle formed between point A, Nasion and Point B) and study the possible correlations between different cephalometric variables and the airway morphology in these children.

MATERIALS AND METHODS

Following the ethical clearance from the institutional review board, records of 150 children who visited the outpatient Department of Orthodontics were examined. Of this, CBCT scans of 120 healthy North Indian children (54 boys and 66 girls mean age 15.19 ± 1.28) were selected, after the following exclusion criteria was applied: History of any upper respiratory infection, pharyngeal pathology (like adenoid hypertrophy and tonsillitis) or a history of adenoid or tonsil removal (Table 1).

CBCT volume scans of all subjects were obtained by using the I-Cat CBCT unit (Imaging Sciences Hatfield, PA, United States), and the imaging protocol used a 17 cm × 21 cm field of view to include the entire craniofacial anatomy. The images were standardized with the subject seated in a chair, machine settings of 120 kV-5 mA-0.25 mm voxel, and scan time of 20 s. Patients, following the standard protocol of acquiring the scans in a natural head position, and their jaws in maximum intercuspation with the lips and tongue in resting position were used. For volume evaluation/measurement and cephalometric analysis, the axial images were transferred to InVivo Dental software (Anatomage, San Jose, CA, United States) The 3D images were reoriented using the Frankfort horizontal (FH) plane as the reference plane for uniformity and to reduce errors. A line joining the right and left portions, located in the most latero-superior point of the external auditory meatus, to the right orbitale was constructed as the FH plane (Figure 1).

2D cephalometric images were derived from the CBCT scans by using SUPER CEPH feature of the software In Vivo Dental, and the images were imported into Nemoceph® (Dental Studio NX 2006 version 6.0) (Figure 2). Landmark identifications and physical measurements were performed by the same investigator. Using the software Downs, Steiner, Jarabak, Mc Namara and Tweed Merrifield analysis were done in order to classify patients (Tables 1 and 2).

Cross-sectional views of the pharyngeal airway in the 5 planes: a, represents the length (axial slice) or height (frontal slice) of the airway defined by the greatest distance in the anteroposterior or vertical direction of the airway cross-section; b is the width of the airway defined by the greatest distance in the right and left directions of the airway cross-section and 5 volumes A, right lateral view and B, frontal view of volume rendered images. a, Anterior nasal plane; b, posterior nasal plane; c, upper

Table 1 Sample characteristics

	Group IANB < 4		Group II ANB > 4		Total
	Male	**Female**	**Male**	**Female**	
Subjects (*n*)	26	30	28	36	120
Age (yr)	13-17	13-17	13-17	13-17	15.19 ± 1.28

ANB: The angle formed between point A, Nasion and point B.

Table 2 Two-dimensional cephalometric variables, cross-sectional planes and volumes of the 3-dimensional pharyngeal airway

Two-dimensional cephalometric variables

(1) Gonial angle: Angle formed between line drawn tangent to the lower border of the mandible and another line tangent to the distal border of the ascending ramus and the condyle on both sides; (2) Anterior facial height (AFH): Distance between the Nasion and Menton (Me); (3) Posterior facial height (PFH): Distance between Sella (S) to Gonion(Go); (4) PFH/AFH: Ratio of AFH and the PFH; (5) FMA: Frankfurt Mandibular Plane Angle formed by the intersection of the Frankfort horizontal plane and the mandibular plane; (6) ANB: The angle formed between point A, Nasion and Point B; (7) Facial convexity: Formed by the intersection of line from Nasion to point A, to point A to pogonion(Po); (8) Condylion to point A (Co-PtA); (9) Condylion to gnathion (Co-Gn); and (10) Mandibular body length (Mand-BL): Distance from gonion to pogonion

Cross-sectional planes and volumes of the 3D pharyngeal airway

Anterior nasal plane (Ana plane)	Plane passing through anterior nasal spine (ANS) and perpendicular to FH
Posterior nasal plane (Pna plane)	Plane passing through posterior nasal spine (PNS)and perpendicular to FH
Upper pharyngeal plane (Uph plane)	Plane passing through PNS parallel to FH
Middle pharyngeal plane (Mph plane)	Plane passing through lower margin of the soft palate and parallel to FH
Lower pharyngeal plane (Lph plane)	Plane passing through superior margin of the epiglottis and parallel to FH
Volume	
Nasal airway	Airway formed by the planes between Ana and Pna
Superior pharyngeal airway	Airway formed by the planes between Pna and Uph
Middle pharyngeal airway	Airway formed by the planes between Uph and Mph
Inferior pharyngeal airway	Airway formed by the planes between Mph and Lph planes
Total airway	Airway extending between Ana plane to Lph plane

FH: Frankfurt horizontal; 3D: Three-dimensional.

pharyngeal plane; d, middle pharyngeal plane; and e, lower pharyngeal plane (Table 3 and Figures 3 and 4). Cross-sectional planes of the nasal cavity were perpendicular to the FH plane, whereas the pharyngeal cross-sections are parallel to the FH plane. Although these cross-sections are not directly perpendicular to the long axis of the airway, the FH plane was used as a reference plane to standardize the plane orientation and minimize error in identifying the studied cross-sectional planes. Cross-sectional measurements, that is width and length, were computed in frontal and axial views to provide linear accuracy.

Volumetric renderings of the subjects' CBCT scans were acquired with the In Vivo Dental software, and we proceeded with volumetric analysis of the defined airways. 3D image inversion to convert negative image to a positive value was done, which is required as the airway is a void space. This process removes the hard and soft tissues of the image around the airway and embodies the airway spaces of the craniofacial region including the paranasal sinuses and other empty spaces. Furthermore, to isolate the required airway section and remove structures that were not necessary, sculpting was performed which was an inherent feature of the software. Threshold values were thereafter altered to remove the artifacts and enhance the selected region of airway. Lastly, designated airway volume was computed in cubic millimeters.

Statistical analysis

Descriptive statistics including the mean and standard deviation for each group were calculated by using SPSS for Windows software (version 20). Differences between

Table 3 Correlations of sections of the airway with each other

	Nasal airway	Superior airway	Middle airway	Inferior airway	Totalairway
Nasal airway					
Pearson correlation	1	0.085	0.471[a]	0.386	0.879[b]
Sig.(2-tailed)		0.722	0.036	0.093	0
n	120	120	120	120	120
Superior airway					
Pearson correlation	0.85	1	0.494[a]	0.651[b]	0.4623[a]
Sig.(2-tailed)	0.722	-	0.027	0.002	0.04
n	120	120	120	120	120
Middle airway					
Pearson correlation	0.471[a]	0.494[a]	1	0.763[b]	0.779[b]
Sig.(2-tailed)	0.036	0.027	-	0	0
n	120	120	120	120	120
Inferior airway					
Pearson correlation	0.386	0.651[b]	0.763[b]	1	0.744[b]
Sig.(2-tailed)	0.093	0.002	0	-	0
n	120	120	120	120	120
Totalairway					
Pearson correlation	0.879[b]	0.4623[a]	0.779[b]	0.744[b]	1
Sig.(2-tailed)	0	0.04	0	0	-
n	120	120	120	120	120

[a]Correlation is significant at 0.05 level.

[b]Correlation is significant at 0.01 level.

groups were tested by using independent *t* tests. Pearson's correlation coefficient test was used to detect any relationship of different parts of the airway and between airway volume and 2D cephalometric variables.

RESULTS

Means and standard deviations for cephalometric, cross-sectional, and volumetric variables were compared. Table 4 gives the comparison results of groups I and II. ANB, mandibular body length, facial convexity were statistically highly significant ($P < 0.01$) whereas condylion to point A, nasal airway and total airway volume ($P < 0.05$) were statistically significant. Cross-sectional and volumetric measurements at different levels when compared were statistically insignificant. However, total airway volume was significantly greater in group I ($P < 0.05$).

Table 3 show the correlations among the studied variables. The nasal airway volume and the superior pharyngeal airway volume had a positive correlation ($P < 0.01$), nasal airway was correlated to middle ($P < 0.05$) and total airway superior had a relation with middle ($P < 0.05$), inferior and total airway ($P < 0.05$), middle was related to all other airways, inferior was also related to all the airways except nasal (Table 5). Lateral cephalometric values were positively correlated with the airway volume with Frankfurt Mandibular Plane Angle (FMA) and facial convexity showed significant correlations with total airway volume ($P < 0.05$). Additionally, ANB angle was significantly correlated with total airway volume and superior airway ($P < 0.05$).

Table 4 Descriptive statistics of groups I and II

Group	Group I ANB < 4		Group II ANB > 4		P value
	mean	SD	mean	SD	
Ana height	29.63	4.69	30.06	6.73	0.871
Ana width	13.81	1.98	15.24	3.61	0.273
Ana C. area	194.41	13.93	218.14	52.41	0.22
Pna height	29.95	7.85	28.73	8.70	0.744
Pna width	23.88	3.06	24.14	4.84	0.884
Pna C. area	257.85	74.25	284.32	78.01	0.448
Uph length	19.28	6.61	17.54	4.19	0.503
Uph width	26.01	4.81	24.14	7.87	0.522
Uph C. area	293.37	71.56	314.97	99.76	0.58
Mph length	11.67	3.47	11.54	3.60	0.935
Mph width	22.66	5.87	20.16	8.26	0.439
Mph C. area	226.32	85.90	213.25	102.48	0.76
Lph length	14.77	7.93	11.88	3.07	0.286
Lph width	24.44	5.19	28.90	6.76	0.111
Lph C. area	231.31	83.23	199.84	78.36	0.399
Gonial angle	126.37	7.79	125.24	7.55	0.748
AFH	108.38	6.08	112.12	4.86	0.152
PFH	73.06	5.42	71.81	7.58	0.672
PFH/AFH, %	67.47	4.49	64.02	5.83	0.152
FMA	25.06	3.61	27.48	6.02	0.281
ANB	2.85	1.56	6.14	1.02	< 0.001[b]
MAND-BL	66.94	3.74	61.61	4.27	0.008[b]
Facial convexity	5.17	3.57	10.76	4.56	0.007[b]
Co-pt A	82.10	6.09	82.68	3.44	0.802
Co-pt GN	109.83	5.54	103.72	6.42	0.035[a]
Nasal airway	36407.36	2526.59	30446.00	7060.88	0.037[a]
Superior airway	5563.27	1350.80	4559.67	1263.62	0.106
Middle airway	5322.45	2124.81	4213.89	1291.90	0.188
Inferior airway	5487.82	2018.25	5077.67	1521.36	0.621
Total airway	52780.91	6435.84	44297.22	8662.49	0.022[a]

[a]Correlation is significant at 0.05 level.
[b]Correlation is significant at 0.01 level.
ANB: The angle formed between point A, Nasion and point B; Ana: Anterior nasal; Pna: Posterior nasal; Uph: Upper pharyngeal; Mph: Middle pharyngeal; Lph: Lower pharyngeal; AFH: Anterior facial height; PFH: Posterior facial height; FMA: Frankfurt Mandibular Plane Angle; Mand-BL: Mandibular body length; Co-PtA: Condylion to point; GN: Gnathion; SD: Standard deviation.

DISCUSSION

In the last few decades' airway assessment has been done using nasal resistance and airflow tests, nasoendoscopy and lateral cephalograms[15]. In the current study, CBCT produced anatomically precise images, sans magnification or distortion were reconstructed 3 dimensionally to completely understand the pharyngeal airway anatomy of growing children in all dimensions (sagittal, transverse and frontal)[11,14]. Generally, a requisite for 3D imaging such as conventional CT or magnetic resonance

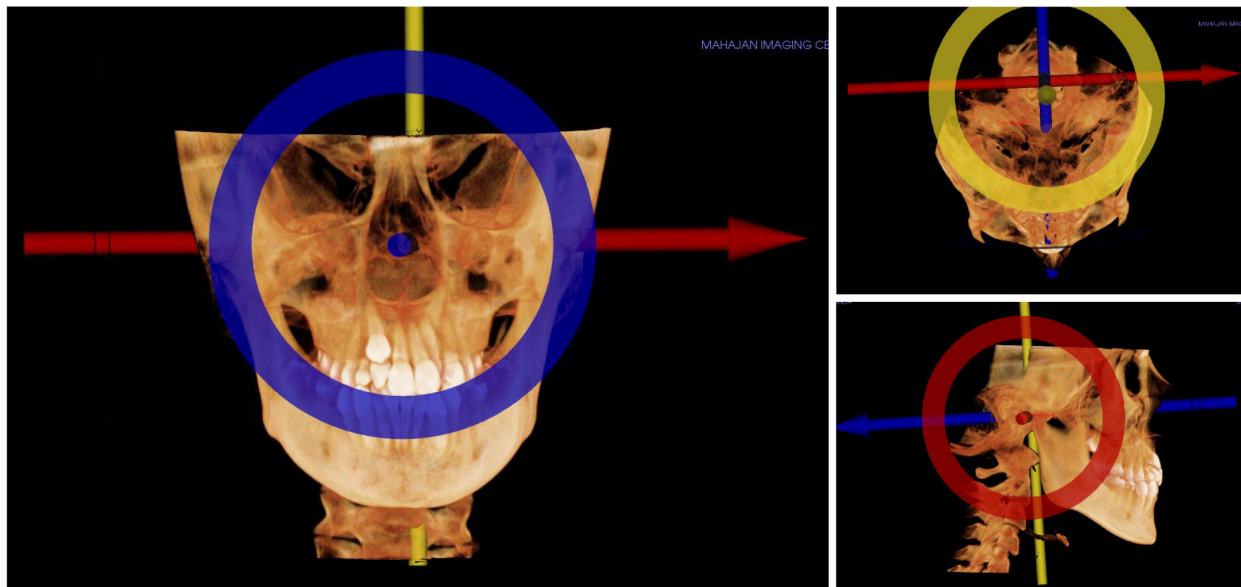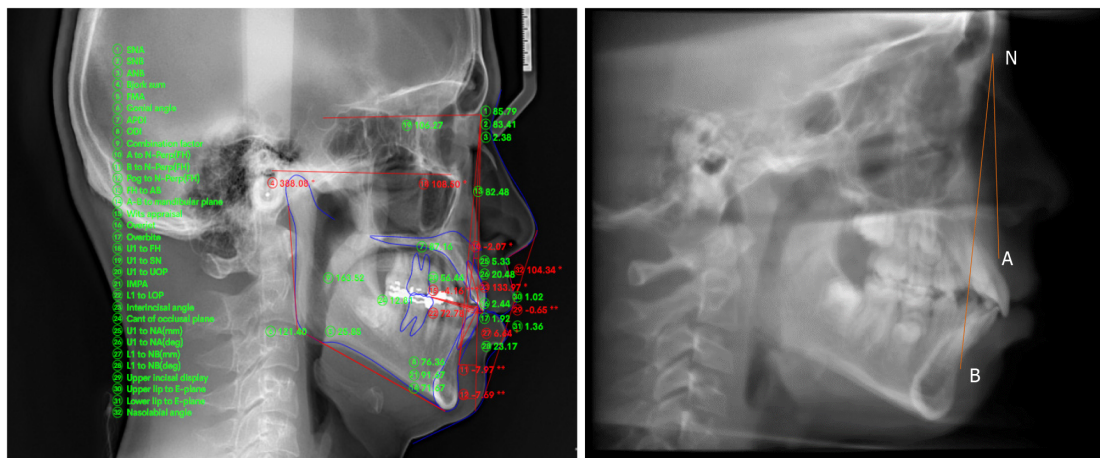| Table 5 Correlations between the 2-dimensional cephalometric variables and the 3-dimensional volumetric measurements of the airway					
	Nasal airway	**Superior airway**	**Middle airway**	**Inferior airway**	**Total airway**
Gonial angle					
Pearson correlation	-0.021	0.135	0.098	-0.019	0.024
Sig.(2-tailed)	0.928	0.571	0.681	0.937	0.918
n	120	120	120	120	120
AFH					
Pearson correlation	0.055	0.201	0.057	0.342	0.154
Sig.(2-tailed)	0.818	0.395	0.811	0.14	0.517
n	120	120	120	120	120
PFH					
Pearson correlation	0.159	0.172	0.124	0.319	0.23
Sig.(2-tailed)	0.503	0.47	0.602	0.171	0.329
n	120	120	120	120	120
PFH/AFH, %					
Pearson correlation	0.133	0.057	0.086	0.113	0.142
Sig.(2-tailed)	0.576	0.813	0.717	0.636	0.55
n	120	120	120	120	120
FMA					
Pearson correlation	-0.372	-0.314	-0.377	-0.411	-0.473[a]
Sig.(2-tailed)	0.106	0.178	0.102	0.072	0.035
n	120	120	120	120	120
ANB					
Pearson correlation	-0.364	-0.408	-0.197	-0.152	-0.389
Sig.(2-tailed)	0.115	0.034[a]	0.405	0.522	0.22[a]
n	120	120	120	120	120
Mand-BL					
Pearson correlation	0.136	0.523[a]	0.038	0.184	0.225
Sig.(2-tailed)	0.567	0.018	0.874	0.436	0.341
n	120	120	120	120	120
Facial convexity					
Pearson correlation	-0.362	-0.306	-0.221	-0.22	-0.391
Sig.(2-tailed)	0.116	0.189	0.349	0.351	0.088
n	120	120	120	120	120
Co-pt A					
Pearson correlation	0.127	0.324	0.289	0.469[a]	0.3
Sig.(2-tailed)	0.594	0.163	0.217	0.037	0.199
n	120	120	120	120	120
Co-pt GN					
Pearson correlation	0.301	0.296	0.012	0.225	0.303
Sig.(2-tailed)	0.197	0.204	0.959	0.34	0.194
n	120	120	120	120	120

Figure 1 Standardisation of the images.

Figure 2 Cone beam computed tomography derived cephalogram and analysis.

imaging is for the patients to be supine. However, due to the effect of gravity on the soft tissues enveloping the oropharyngeal cavity, there are substantial anatomical changes in the airway[16].

Hsu *et al*[17] further found that the minimum of PAS and linear distance along perpendicular changes from the most upper anterior point of the hyoid bone to mandibular plane, as the position of body is changed from upright to supine[17]. Nevertheless, in recent times, advancements in CBCT have permitted axial CT images to be acquired in upright sitting posture, which is more valid for our study.

Owing to this study's retrospective design, direct examination of the nasopharyngeal functions of the patients was not possible and previous clinical charts and diagnoses for orthodontic treatment were used to select subjects. Nonetheless, a study by Laine-Alava *et al*[18] stated that there is no effect of a history or symptoms of upper respiratory disease on variables related to naso-respiratory function when the
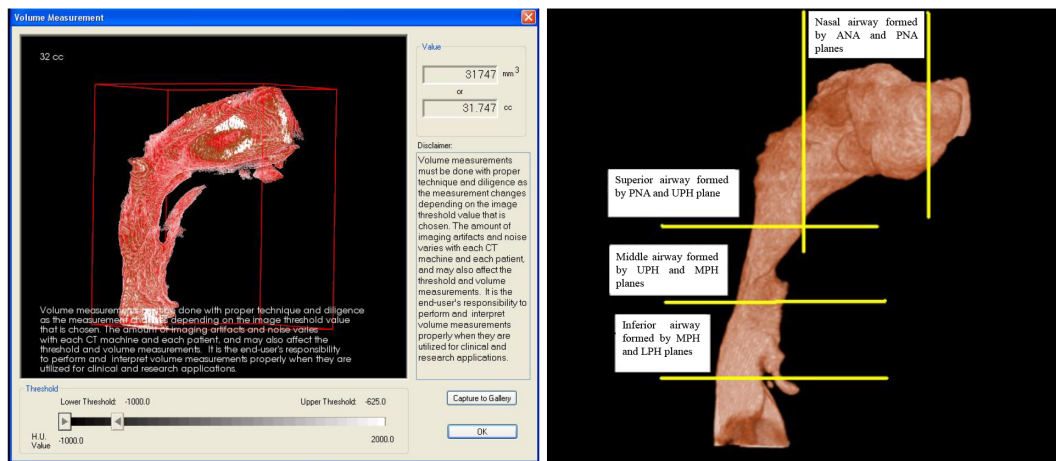
Figure 3 Airway isolated with the software and various referencing plane. ANA: Anterior nasal; PNA: Posterior nasal; UPH: Upper pharyngeal; MPH: Middle pharyngeal; LPH: Lower pharyngeal.

measurements are made during an asymptomatic period, which justifies the retrospective format of our study[18].

2D lateral cephalometric images were created from the CBCT scans to allocate the subjects to the 2 groups, and to assess correlations among the cephalometric parameters and the pharyngeal airway volumes. Linear accuracy of the CBCT-derived lateral cephalometric images has been studied in the past[19,20]. The classification of the subjects based on their anteroposterior skeletal relationships, was done utilizing north Indian standards for the ANB angle[21].Additionally, previously it has been demonstrated that the prepubertal ANB angle and the angle of convexity measured have high prediction accuracy for postpubertal anteroposterior jaw relationships[19,22]. In the current study, the anteroposterior analyses displayed statistically significant differences further confirming that the ANB angle, which was used to classify our subjects, was a reliable parameter[22].

Previous studies have presented excellent intra-rater reliability values of InVivo 5 software, hence in the present study the InVivo 5 software was used to analyse the pharyngeal volume[14,23]. In the current study, no sexual dimorphism in any cross-sectional and volumetric measurements was observed between the two sexes. These findings were in agreement with the study by Ceylan *et al*[24] and de Freitas *et al*[25]. Similarly, in a study by Xu *et al*[26] in 2019, no significant difference was observed in patient sexas well as age.

In groups I and II ANB, mandibular body length and facial convexity were statistically highly significant ($P < 0.01$) whereas condylion to point A, nasal airway and total airway volume ($P < 0.05$) were statistically significant. Although group I demonstrated greater cross-sectional areas and volumetric measurements of the sub-regions of the pharyngeal airway, this was statistically insignificant signifying lack of correlation between segmental airway capacities and mandibular deficiencies. This was in accordance with Di Carlo *et al*[27] who did not find a direct correlation between individual skeletal patterns, and overall upper airway anatomy. Moreover, former 2D studies also asserted a lack of relationship between airway dimensions and malocclusion class[24,25]. Ceylan *et al*[24] stated that despite skeletal anteroposterior relationship changes, the airway dimensions remain constant, owing to postural changes in the pharyngeal structures. However, certain authors emphasized that upper airway dimensions vary according to different skeletal classes, developmental ages, and gender[1].

Nasal airway was positively correlated with middle and total airways. This may be justified by the location of the 2 sections, that are just superior to hard palate and not anatomically adjacent, yet there is direct correlation of their volumetric dimensions. The sections superior airway with middle, inferior and total airway and inferior airway with superior, middle and total airway display significant correlations. According to Ricketts[3] and Dunn *et al*[28], a restricted nasopharyngeal airway width is associated with mouth breathing, because it is readily obstructed by adenoid enlargement. Total airway was positively correlated with all superior, middle and inferior airways in our study.

The negative correlation of the ANB angle and the total airway can be explained by
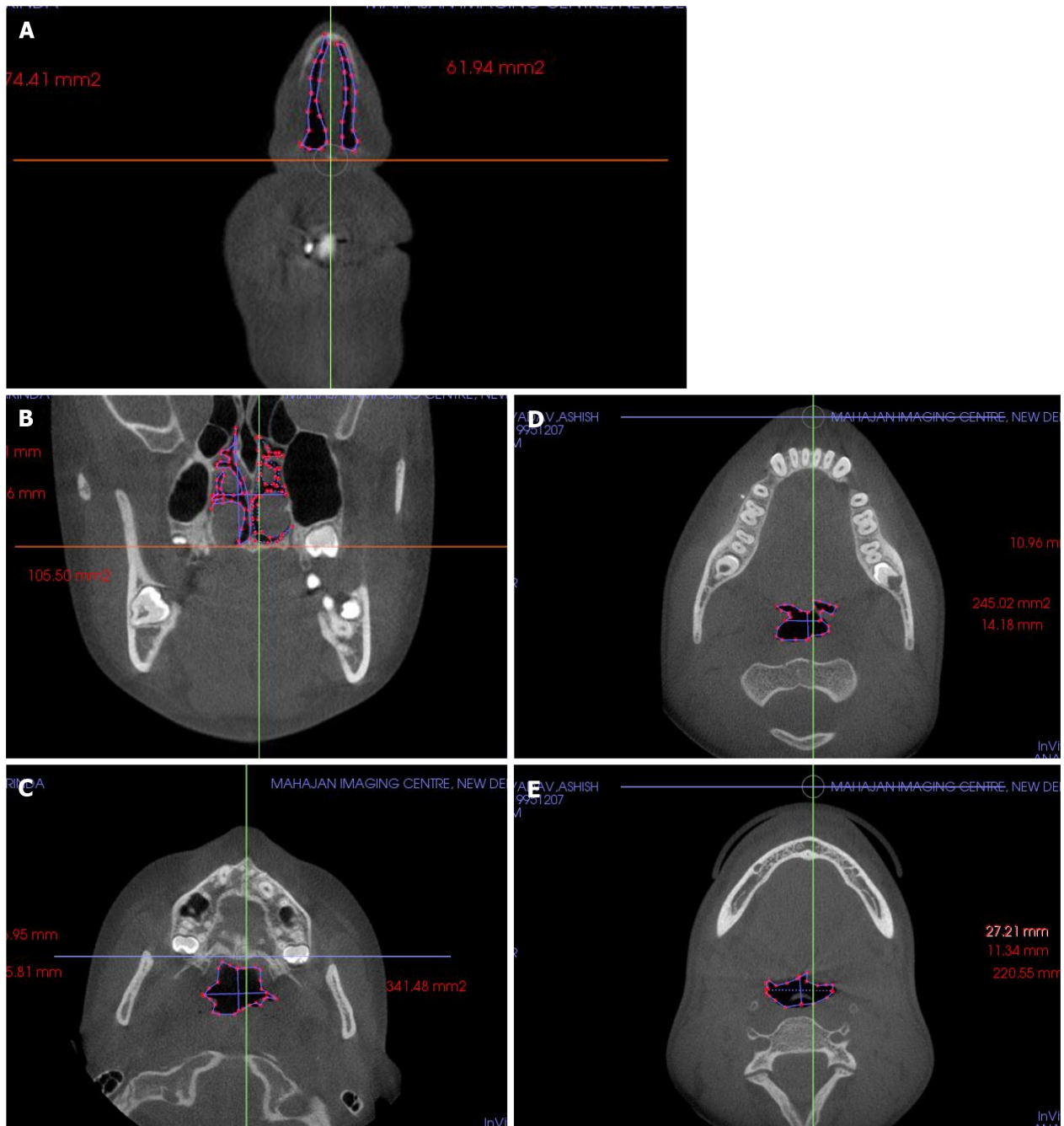
Figure 4 Horizontal section showing airway. A: Nasal; B: Superior; C: Middle; D and E: Inferior airway.

group I (ANB less than 4) having significantly greater airway volume than group II (ANB more than 4). Mandibular body length and total airway volume were both significantly greater in group I, demonstrating a positive correlation. Total airway volume had significant association with ANB angle and mandibular body length (anterior-posterior discriminants) supporting the intergroup comparison of different anterior-posterior skeletal patterns in the study. Similar results were observed by Lopatienė *et al*[29], where statistically significantly narrower airways were found in patients with ANB more than 4.

Alhammadi *et al*[30] and Xu *et al*[26] also concluded that patients with skeletal Class II presented with reduced glossopharyngeal airway volume, larger total minimum constricted area in average faces and more nasal minimum constricted area in long faces. Hwang *et al*[31] reported that a constricted nasopharyngeal airway is associated with retruded mandible and maxilla.

A significant correlation exists between the skeletal facial pattern and upper airway dimensions according to a study done by Shokri *et al*[32], who concluded that the total

airway volume and the mean airway area of class III patients were larger than those in class II patients.

Limitation

In the present study we did not evaluate class III malocclusion patients, also all the patients were scanned in a sitting upright position so conclusion about obstructive sleep apnea cannot be derived. But there is strong evidence from the large sample size that mandible backward position is correlated with reduced airway.

CONCLUSION

The mean total airway volume of patients with ANB more than 4 was significantly smaller than that of patients with ANB less than 4. The sub volumes in the pharyngeal airway showed a positive correlation with each other. FMA and facial convexity and mandibular body length also had a significant interrelationship with total volume of airway.

ARTICLE HIGHLIGHTS

Research background

Diminished airway associated with obstructive sleep apnea tends to be typical in patients with Angle class II malocclusion, displaying retrognathic mandible and sagittal discrepancy. Early diagnosis and evaluation of the functional factors in growing children with skeletal discrepancy and features of adenoid hypertrophy (adenoid faces) might be pivotal to restore proper craniofacial growth and treatment outcome stability.

Research motivation

A lot of data has been published related to the identification of airway in the general population, even comparing different cone beam computed tomography machines for the same. However, there is a paucity of data on tomographic evaluation of airways in different skeletal patterns, which is often challenging due to their morphology and plays a vital role in their treatment planning.

Research objectives

Comparing the airway volumes in patients with mandibular retrognathism and those with the normal anteroposterior skeletal relationship.

Research methods

Cone-beam computed tomography volume scans, and lateral cephalograms, 3-dimensional airway volume and cross-sectional areas of 120 healthy children which were done for orthodontic assessment was evaluated. The subjects were divided into 2 groups based on the angle formed between point A, Nasion and Point B (ANB) values and cephalometric variables (such as anterior and posterior facial height, gonial angle *etc*.) airway volumes, and cross-sectional measurements were compared using independent *t* tests. Pearson's correlation coefficient test was used to detect any relationship of different parts of the airway and between airway volume and 2-dimensional cephalometric variables.

Research results

Means and standard deviations for cephalometric, cross-sectional, and volumetric variables were compared. ANB, mandibular body length, facial convexity was statistically highly significant whereas condylion to point A, nasal airway and total airway volume were statistically significant. The nasal airway volume and the superior pharyngeal airway volume had a positive correlation, nasal airway was correlated to middle and total airway superior had a relation with middle, inferior and total airway, middle was related to all other airways, inferior was also related to all the airways except nasal. Lateral cephalometric values were positively correlated with the airway volume with Frankfurt Mandibular Plane Angle and facial convexity showed significant correlations with total airway volume. Additionally, ANB angle was significantly correlated with total airway volume and superior airway.

Research conclusions

Position of the mandible has positive correlation with the airway volume. Retrognathic mandible showed decreased overall airway in patients. Facial convexity and length of the mandible also influence the airway.

Research perspectives

The current study gives direction for future research on a larger cohort related to mandibular position and airway, linking the two for timely maxillo-facial orthopedic treatment interventions.

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