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ASSOCIATION OF CRANIOFACIAL MORPHOLOGY WITH AIRWAY DIMENSION AND VOLUME

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ABSTRACT

Objective: To compare upper airway volume, lower airway volume and total airway volume between the Class II Division 1 and Class II Division 2 individuals, using Cone Beam Computed Tomography scans.

Study Design: Cross-sectional analytical study.

Place and Duration of Study: Orthodontics department, Armed Forces Institute of Dentistry, Rawalpindi, from Jan 2017 to Dec 2018.

Methodology: It was a cross-sectional study in which a comparison between upper airway volume, lower airway volume and total airway volume was drawn between the Class II Division 1 and Class II Division 2 individuals, using Cone Beam Computed Tomography scans. Independent sample t test was applied for testing the statistical significance between mean scores of the groups.

Results: Results suggested that difference among upper and lower airway volumes among the two groups was statistically significant. Upper airway in Division 1 group was 8870.02 ± 454.53mm^3 as compared Division II 9402.00 ± 80.76 mm^3, with a *p*-value of 0.04 and lower airway in Division 1 group was 8368.35 ± 41.18mm^3 as compared Division II, 8773.52 ± 185.847mm^3, with a *p*-value of 0.04. Whereas total airway volume showed an insignificant difference with Division I having a total volume of 8368.35 ± 412.18 mm^3 and Division II, 8773.52 ± 185.85 mm^3 with a *p*-value of 0.75.

Conclusion: Class II generally has lesser airway volumes as compared to other facial forms. Among class II, Division 2 profile has greater values of upper and lower airway volumes when compared to Division and total airway volumes are not statistically different among Division 1 and 2.

Keywords: Airway assessment, Airway morphology, Airway volume, Cone beam computed tomography, 3D evaluation.

INTRODUCTION

Oral cavity is strategically located and anatomically designed to perform a multitude of functions. Respiratory function as well as upper airway morphology not only are complex and multifunctional neuromechanical systems[1], but also are greatly related to normal development of orofacial structures. Altered breathing function could influence facial growth and morphology[2] and vice versa. Growth, anatomical, postural and mechanical factors[3] greatly influence the dimensions of a healthy pharyngeal airway. Mandibular deficiency, maxillary hypoplasia, inferior position of hyoid bone and elongation of the soft palate can lead to compromised airway space[4]. Craniofacial form and function are closely interlinked, growth and morphology of the surrounding bony framework directs the enlargement of the pharynx whereas converse may also be true[5-7]. Relationship between impaired pharyngeal ventilation and malocclusion has been a controversial subject but several studies have showed them to be positively correlated[8].

A variety of treatment modalities have been used to address the problems related to obstruction or insufficiency of airway in adult non growing population. Being an orthodontist, we are ata critical standpoint of diagnosing the insufficient airway during the growth periods and at that very point, addressing the growth aberrations may prove to be significant in improving the insufficiency of the developing

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airway. Some local etiological factors, like mandibular and maxillary insufficiency (retrognathism), maxillary transverse constriction, soft tissue enlargements of adenoids and tonsils, abnormal tongue size or posture, altered breathing habits including persistent mouth breathing are the ones that present as common findings to orthodontist during routine treatment planning. Early diagnosis, evidence-based explanations of etiology, and assessment of the functional factors might be vital for the restoration of the normal craniofacial growth and the stability of the treatment results[9]. We may say that this early diagnosis and addressing the etiological factors may work as a vaccine to prevent future development of insufficient airway.

In some previous studies, it was found that skeletal Class III patients had greater airway volume than class I, which was greater than skeletal Class II patients[10]. Conflicting results have been reported regarding minimal cross-sectional area and sagittal craniofacial dimension; some studies have found an association[10], whereas others have not. The objective of the study was to compare upper airway volume, lower airway volume and total airway volume between the Class II Division 1 and Class II Division 2 individuals, using Cone beam computed tomography (CBCT) scans.

METHODOLOGY

The study was approved by ethics review committee (Ref letter number: 905/Trg-AB1K2) of Armed Forces Institute of Dentistry (AFID). It was a cross-sectional analytical study in which patients opting for orthodontic treatment in AFID were selected by using a non-probability consecutive sampling technique. Sample size was calculated using G-power 3.1.9.2 software. For an independent sample t-test, keeping the value of effect size as 0.8, alpha error as 0.05, beta error as 0.2, probability and power 0.8, a sample size of 50 was calculated, with 25 subjects falling in each group. After orientation of acquired CBCT records on axial and coronal planes, 3 scans from division 1 group and 5 scans from division 2 group were dropped out for not being properly oriented whereas 1 scan from division 1 group and 2 scans from division 2 group were dropped out as result of movement artifact during accusation. Consequently the division 1 group now comprised of a total scans of 22 and division 2 group had 18 scans. Written informed consent was obtained from all subjects before using their records for the study.

Data included scans acquired from January 2017 to December 2018. Inclusion criteria was formulated and subjects with age between 13 years to 20 years, biting in centric occlusion, full field of view images (18-16 cm) [including cranial base, maxilla, mandible, the first four cervical vertebrae (C1–C4) and the associated airway], Class II skeletal relationship with an ANB angle of 4.5° or more were included. To confirm that skeletal discrepancy lies in the lower jaw alone, subjects with SNA between 80 degrees to 84 degrees were included. Scans of subjects only with normal tongue sizes and posture, which was confirmed by clinical evaluation (tongue tip to chin and swallowing test respectively) were included. Of all the patients fulfilling our inclusion criteria, subjects with Class I and Class III (prognathic mandible) Class II (prognathic maxilla) skeletal relationship, having previous orthodontic treatment and/or orthognathic surgery, adeno-tonsillectomy, known syndromal conditions, presence of pathology/trauma in craniofacial region, any history of obstructive sleep apnea (OSA) or treatment received for OSA, 3D scans having movement artifacts or swallowing during scan acquisition were excluded from the study.

The CBCT data sets included in this study were acquired in accordance to the department's protocol of imaging using the New Tom VGi 3D [QR systems, Verona, Italy]. Scans were done with patients positioned in the upright position, making the Frankfort horizontal (FH) plane parallel to floor. They were instructed to maintain maximum intercuspation and to avoid swallowing and other movements during the scanning procedure. The exposure settings were 110 kV, 4 mA, 18-16 cm field of view, 0.3-mm voxel size, 3.6 seconds exposure time. For analysis, the images were saved as digital imaging and communications in medicine (DICOM) software files.

Sagittal skeletal type was established initially from visual inspection of the facial photographs and the lateral cephalometric radiograph. This was confirmed by measuring ANB angle, overjet and mandibular length on synthetic lateral cephalogram. Differentiation between division 1 and division 2 was made as class II division 1 was categorized by having over jet >3mm, class II division 1 incisor relationship (proclined incisors), SN to MP angle >30 degree whereas division 2 was categorized as overjet <3mm, Class II division 2 incisor relationship (retroclined incisors), deep overbite and an SN to MP angle <30 degree First, scans were oriented to static reference planes, in frontal and lateral view. The midsagittal plane was paralleled to the skeletal midline and the coronal plane matched the line passing from the right and left inferior orbital rim. Also on the lateral view, the Frankfort plane was paralleled axial plane and coronal plane was paralleled to line passing along the pterygomaxillary groove. Six degree orientation between SN plane and Frankfort Horizontal was also established to confirm that the scans were properly oriented. After orientation demarcation of airway was done by demarcating the outline. After the airway was completely outlined in all three planes, the airway volume was calculated by software automatic volume determination tool. Following that comparisons of upper airway volume, lower airway volume and total airway volume were drawn between the Class II Division 1 and Class II Division 2 individuals.

The statistical analysis was carried out using statistical software (version 23; SPSS). Mean was calculated for age whereas frequency and percentage was calculated for and gender. Independent sample t test was applied for testing the statistical significance between mean volumes of the groups (independent sample t-test). A *p*-value less than 0.05 was considered to be significant.

RESULTS

Out of total sample (n=40), 22 (55%) were males and 18 (45%) were females.

Subjects fell in an age range of 18 years to 29 years, with mean of 23.02 ± 2.70 years. All of the subjects were adults whose airways had established their greatest dimensions. Moreover subjects were in such an age range where minimal or no growth potential was remaining. Age that was a confounding factor, as pharyngeal airway volume is changed with the growth, was controlled as mean age of division 1 group was 22.32 ± 2.61 years and division 2 was 22.67 ± 2.85 years. Nature of malocclusion was established with no anticipation of improvement or worsening, as all the subjects had developed fully in anteroposterior and vertical dimensions.

Table: Comparison of airway volumes with skeletal morphological variants of Class II individuals.

	Class II Division 1 (22) Division 2 (18)	Mean Airway Volume with Std. Deviation (mm^3)	Significance Value (*p*-value)
Total Airway Volume	Division 1	17061.52 ± 3429.35	0.75
	Division 2	17330.57 ± 3870.28	
Upper airway Volume	Division 1	8870.02 ± 454.53	<0.001
	Division 2	9402.00 ± 80.76	
Lower Airway Volume	Division 1	8368.35 ± 412.18	0.04
	Division 2	8773.52 ± 185.85	

Airway volume analysis was performed for each scan in three segments i.e. upper airway volume, lower airway volume and total airway volume. For division 1 group mean upper airway volume was 8870.02 mm^3 ± 454.53, mean lower airway volume was 8368.35 mm^3 ± 412.18, and mean total volume was 17061.51mm^3 ± 3429.35.

For division 2 group mean upper airway volume was 9402.00mm^3 ± 80.75, mean lower airway volume was 8773.52mm^3 ± 185.85, and mean total volume was 17330.57mm^3 ± 3870.28 (table).

Results suggested that difference among upper and lower airway volumes among the two groups was statistically significant with *p*-values of <0.001 and 0.04 respectively. Whereas total airway volume showed an insignificant difference among the two groups with a *p*-value of 0.75. Conclusively upper and lower airway volumes were greater in division 2 groups when compared to division 1, while difference of total airway volume was insignificant between the two groups.

DISCUSSION

Significance of normal airway on craniofacial form and function cannot be overemphasized. It is often difficult to establish a cause effect relationship between upper airway morphology and a specific facial pattern as stated by Zheng *et al* that subjects in class I and III groups had significantly higher volumes than that in the class II group[11], and EI *et al* stated that class II (mandibular retrognathism) subjects had the lowest pharyngeal airway volume[12]. Reason behind this variability seems to be because of their innate multifactorial origin[13]. Altered nasal breathing and shift to oral breathing disturbs neuromuscular equilibrium that is significant enough to develop skeletal malformations like growth aberrations inmaxillofacial region, a class II malocclusion, crossbites and hyperdivergent facial form[14].

Kim *et al*[15] and Alves *et al*[16] have established thatchildren with skeletal class II malocclusions have statistically smaller airway dimensions, indicating the positive correlation of PAS dimensions with anteroposterior skeletal pattern. Uslu-Ackem *et al*[17] reported smallest nasopharyn-geal airway dimensions for class I and class II sub groups (i.e. class II division 1 and class II division 2), in individuals at pre-pubertal growth stage. In our study upper airway volume was found to be statistically lesser in class II division 1 group when compared to class II division 2 in adult population. Similar trend was observed in lower airway space (table-I). As stated by Uslu-Ackem *et al*[17] Division 2 values were smallest of all groups that is in contradiction to our findings as Division 2 group had greater dimensions then division 1.

Our understanding of rationale of greater dimensions in Division 2 group is the horizontal pattern of growth. Upward and forward directed growth rotation leads to a wider airway in Division 2 while downward backward rotation of Division 1 group leads to a narrower airway. The reason for inconspicuous difference of total airway volumes may lie in the lengths of airway columns, Division 2 group may have lesser lengths of airway column in comparison to Division 1, due to forward oriented gradient of growth and resultant short average face heights. Division 2 group by virtue of short average face heights, have a smaller height to width ratio that might have accounted for the inconspicuous difference in total airway volumes among the two groups. To confirm this finding there arise a need of further investigation with standardized protocols to reduce errors of assessment.

Obstructive sleep apnea (OSA) is a disorder of adulthood with highest association of morbidity. Foundation of OSA is laid during developmental stages of airway. In children, cause of OSA is often obstructive tonsillitis and adenoids. Long face syndrome is said to be etiologically associated with upper airway obstruction. Possibility of having disturbed respiratory function[18,19] can be greatly reduced by early correction of a skeletal class II malocclusion, upper nasopharyngeal airway pathology (oversized adenoids or tonsils), or chronic respiratory problems. Appropriate diagnosis and timed interception is the key to the improvement of the facial profile (reducing the incidence of long face syndrome[20,21]) and dentoalveolar relationships and nasopharyngeal airway dimensions. One of the goals of interceptive orthodontics must include early assessment, diagnosis and timely measures to prevent aberrant airway development[22] thereby intercepting retrognathism from developing into a severe form.

In adults, an early interception of developing airway problems will reduce the incidence risk of OSA and improve overall quality of life in old age by alleviating the comorbid disorders of hypertension, cardiac failure, diabetes, stroke and depression. Being an orthodontist, we may play a significant role in reducing the risk, comorbidities and economic burden related to sleep related disorders merely by timely interception of inadequate airways and respiration related disorders.

CONCLUSION

Class II generally has lesser airway volumes as compared to other facial forms. Among class II, Division 2 profile has greater values of upper and lower airway volumes when compared to Division and total airway volumes are not statistically different among Division 1 and 2. Having established a positive correlation between airway and craniofacial form and function, early interception of skeletal discrepancy may lead to an improved airway with beneficial effects in reducing obstructive sleep disorders.

CONFLICT OF INTEREST

This study has no conflict of interest to be declared by any author.

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