IMPACT: International Journal of Research in Applied, Natural and Social Sciences (IMPACT: IJRANSS)
ISSN (P): 2347–4580; ISSN (E): 2321–8851
Vol. 10, Issue 3, Mar 2022, 9–28

EVALUATION, COMPARISON AND VOLUMETRIC ANALYSIS OROPHARYNGEAL AIRWAY IN SKELETAL CLASS I AND II INDIVIDUALS WITH DIFFERENT VERTICAL GROWTH PATTERNS: *A MRI STUDY*

Dr Sandhya Lohakare

Professor, Nanded Rural Dental College, Nanded, India

Received: 16 Mar 2022 **Accepted:** 18 Mar 2022 **Published:** 21 Mar 2022

ABSTRACT

A patent airway is one of the important factors for the normal growth of the cranio facial structures 1. Nasorespiratory function and its relation to cranio facial growth is of great interest, not only for the ortho dentist but for paediatricians, otorhinolaryngologists, speech pathologists and other members of healthcare community. The normal growth of the skull is closely associated with the growth and function of thenasalcavities, thenasopharynx and theoropharynx.

KEYWORDS: *Oropharyngeal Airway*

INTRODUCTION

The effects of breathing and its participation in cranio facial growth and development have been the objective of orthodontic diagnoses and treatment plans. Alterations in upper airway breathing, may affect the development of structures and functions of the stomatognathic system during facial growth.

The size of the pharyngeal airway space is of importance in its relationship to themorphology of the face including mandible. Nasal breathing becomes difficult and mouth breathing becomes necessary because of the reduction of the nasopharyngeal airway space[1].

Harvold[2] reported that the lower border of the mandible becomes steeper and the gonial angle increases in mouth-breathing animals. The lowering of the mandible was followed by a downward displacement of the maxilla. Thus, achangein breathing pattern led to a variety of skeletal and dental deformities in subjects that do not ordinarily develop malocclusions.

The pre disposing factors for obstruction of the pharyngeal airways are allergies, environmental irritants and infections, which area menable to adequate treatment and also natural anatomical pre disposition of narrower airway passages[3].

The pharynx is a tube shaped structure which is formed by muscles and membranes. It is located behind the nasal and oral cavities which extends from the cranial base to the level of the sixth cervical vertebra and the lower border of the cricoid cartilage. Its length is approximately 12 to 14 cm. It is divided into three parts: nasopharynx, oropharynx, and hypopharynx[4].

Thenasopharyn geal airway (NA) is a cone-shaped tube that consists of muscles and mucosa. It also includes the adenoid, a complex network of lymphatic tissues located in the posterior area. In growing children, predisposing factors, repeated infection or inflammation usually lead to adenoidhy pertrophy and constriction of the posterior airway. Children with narrowed nasopharyngeal airway tend to use mouth breathing because of partially impaired nasal respirationfunction[5].

The oropharyngeal airway (OA) lies between the soft palate and the hyoidbone. Many reports have demonstrated a relationship between various malocclusion patterns and variations in the size and form of the oropharyngeal airway caused by palate and/or tongue position[6]. The hypopharynx is the area of the pharynx caudal to the epiglottis.

The nasopharynx and the oropharynx have significant locations and functions because they form a part of the unit in which respiration and deglutition are carried out. The nasal portion of the nasopharynx has bony elements in its wall, thus rigid whereas pharyngeal part is contractile as a result of the muscular nature of its wall[4].

Nasalobstruction which is secondary to hypertrophiedinferiorturbinates, adenoidal pad hypertrophy and hypertrophy of the faucial tonsils can cause chronic mouth breathing, loud snoring, obstructive sleep apnea, excessive daytime sleepiness and even cor pulmonale. In this situation, a number of postural changes such as mandible posture, downward and forward positioning of the tongue and extension of the head can take place. If these postural changes continue for along period, especially during the active growth stage, then different levels of severity indent facial disorders, inadequate lip structure, long face syndrome and adenoid facies can beseen[4].

Evaluation of the airway has become an important aspect in orthodontic treatment planning. An excellent way to identify the symptoms of airway disorders is by evaluating the initial orthodontic screening. Clinical detection of structural narrowing of the upper airway may facilitate early recognition of obstructive sleepapnea[7].

The methods to view the airway includes cephalometricradiographs, CBCT, and MRI. Lateral cephalometricradio graphs were the only method used before CBCT and MRI. This method had the limitation of imaging a 3D structure in 2 dimensions. Volume and cross-sectional areas could not be accurately assessed with lateral cephalometricradio graphs[6]. Some additional limitations with lateral cephalometricradio graphs are image magnification orenlargement, distortion, structure overlap, limited identifiable landmarks, and positioning problems[8]. Recently, it has become possible for magnetic resonance imaging (MRI) to determine accurately the pharyngeal airway volume. The development and implementation of MRI for the assessment of OSAS has provided useful information on structural alterations in the pharyngeal airway, the location of abnormal sites, and the severity of apnea. As magnetic resonance imaging (MRI) provides excellent soft tissue resolution and three dimensional reconstruction, MRI is consideredasa diagnostic modalityforOSA[9].

Thus, evaluation of upper and lower airway space should be an integral part of diagnostic and treatment planning, so as to achieve functional balance and stability which is essential. Hence this study is aimed to measure the airway volume and dimensions in skeletal Class I and Class II vertical ("hypo-divergent" and "hyper-divergent) skeletal patterns.

AIM AND OBJECTIVES

Aim

The present study aimed to evaluate the pharyngeal airway dimensions of individuals presenting with the different growth patterns in skeletal Class I and Class II malocclusions using MRI.

Objective

- To evaluate the pharyngeal airway dimensions in skeletal Class II individuals with Hypo divergent growth pattern.
- To evaluate the pharyngeal airway dimensions in skeletal Class II individuals with Hyper divergent growth pattern.
- To evaluate the pharyngeal airway dimensions in skeletal Class I individuals.
- To compare volume of the pharyngeal airway in skeletal Class I and Class II individuals with Hypo divergent growth pattern.
- To compare volume of the pharyngeal airway in skeletal Class I and Class II individuals with Hyper divergent growth pattern.
- To compare volume of the pharyngeal airway in skeletal Class II individuals with Hypo divergent and Hyper divergent growth pattern.

MATERIALS AND METHODS

The present study was carried out to evaluate and compare the upper and lower pharyngeal airway volume, width and area in skeletal Class I and Class II hypo-divergent and hyper-divergent skeletal pattern. A total of 60 patients between the age group of 16 to 30 years which were grouped into skeletal Class I (n=20), Class II hypo-divergent (n=20) and hyper-divergent skeletal pattern (n=20) were selected from the Department of Orthodontics and Dento facial Orthopaedics of our institute. The study was initiated after the clearance from the Institutional Ethics Committee.

Inclusion Criteria

- Patientsaged16-30years.
- Patients desiring orthodontic treatment.
- Patients with skeletal Class I and II hypo divergent and hyper divergent facial form.

Exclusion Criteria

- Patients with history of orthodontic treatment.
- Patients with congenital anomalies.
- Patients with history of adenoidectomy ortonsillectomy.
- Patients with nasal obstruction or any other symptoms of respiratory pathology.
- Patients with history of surgery in the head and neck region.
- Patients with neuromuscular disorder.
- Patients with history of trauma.

Methods

Samples were classified according to the following parameters:

Establishment of Study Groups

Antero-posterior and vertical skeletal type was established from the pre-treatment lateral cephalogram.

- Antero-posterior skeletal type: The study sample was categorized in Class I and II skeletal patterns with ANB angular measurements. This refers to the skeletal Class or the relationship between the maxilla and the mandible with respect to the cranial base. For that, the Steiner's ANB angle was used (Class I =2º ± 2º, Class II >4º)[68].
- Vertical skeletal pattern. This refers to the vertical craniofacial growth of the mandible with respect to the cranial base. Sella-Nasion to Gonion-Gnathionangle (SN.GoGn) that is the angle between S N and Steiner's mandibular planes was used to divide the sample into hypo divergent, Normo divergent, hyper divergent growth patterns with values of < 32°, 32° and > 32° respectively.
- Lateral cephalo metric radiographs were taken in a cephalostat (Kodak 8000cG-XR-29461 machine). All subjects were positioned in the cephalo stat with the sagittal plane at a right angle to the path of the x-rays and the Frankfort plane was parallel to the horizontal plane and the teeth were in centric occlusion. All radio graphs were manually traced and whole angular and linear measurements were recorded by a single investigator and were reviewed twice by other investigators for accuratel and mark identification.

Acquiring Image Data

Studies were performed using a 1.5 Tesla magnetic resonance imaging scanner (GE health care) (fig.1). Since head and neck position may alter upper-airway soft-tissue configuration and upper-airway geometry[69,70], subjects were aligned in the Frankfort plane (a plane bisecting the soft tissue of the orbit and the tragus of the ear, perpendicular to the scanner table) prior to the scanning. Foam pads were placed between the patient's head and volume neck coil was received each side to ensure that head movement did not occur during the MRI scanning. Throughout the scan, patients remained in the supine position and were instructed to breathe normally through their nose and were encouraged to refrain from swallowing. All images were taken during wakefulness which was ensured with frequent communication with the subjects. Each study was initiated with a 3.5-minute sagittal localizing spin echo scan [TR (repetition time)=400.0 ms, TE (echo time)=16.0 ms, 256x128 matrix, 1 NEX, flip angle=90°,FOV(field of view)=24.0 cm, slice thickness of 3.0 mm, and 1.5 mm, skip to establish the rostral and caudal margins of the upper airway (roof of the nasopharynx and the base of larynx). Subsequently, a 4.0-minute contiguous axial T1-weighted spin echodata set (TR=400.0 ms, TE=16.0 ms, 0.5 NEX, flip angle=90°, FOV=24.0 cm, slice thickness of 5.0 mm and 0.0 mm skip) was acquired from the roof of the nasopharynxto the vocal cords.

Anatomic Definitions and Measurements

To build 3D models of the airways for the 60 subjects, the MRI data were loaded into Insight SNAP software (version 1.4.0, Cognitica, Philadelphia, Pa). There are 2 inter active steps to these gmentation: selection of an initial threshold and placement of initial seed regions[71]. The segmentation process is then defined as the construction of 3 D virtual surface models (called segmentations) by regional growth of the initial seed region stomatch best the volumetric data. This segmentation method has been described, validated, and tested for accuracy which is superior to the conventional slice-by-slice, manual tracing method. The limits for segmentation and an example of a virtual surface model of the pharyngeal airway are shown in the following figure.

Once segmented, the pharyngeal airways were refined to obtain the true shape of the airway by eliminating projections that did not belong to the airway and then were subdivided into superior and inferior compartments by a plane per pendicular to the sagittal plane that included the posterior nasal spine and the lower medial border of the fourth cervical vertebra.

Airway volumes were measured in cubic milli-meters with the Insight SNAP measuring tool. The limits adopted for the upper pharyngeal portion were those proposed by Eland Palomo[72] (fig 2). The upper limit of upper pharyngeal portion was defined in the sagittal view as the line uniting the posterior nasal spine and the So(middle point of the sella-basion line) points[45]and its posterior limit was defined in the sagittal view as a line approximately perpendicular to the palatal plane that intersects the So point and the lower limit of then as opharynxsegment was the palatal plane (fig3).Thelowerpharyngealportion'supperlimitwasthepalatalplaneextendedtotheposteriorpharyngealwall,andthelowerlimitw astheplaneparallelto the palatal plane that intersected the lower and most anterior point in the fourth cervical vertebra and epiglottis (fig 4).

The airway transverse width (fig 6) and area (fig 5) were determined at the same levels, that is at the hard palate (upper) and lower and most anterior point in the fourth cervical vertebra (lower) were measured.

These measurements were made on an axial section and the average distances were registered.

Assay Procedure Summary

Patients were selected from the Department of Orthodontics and Dento facial Orthopaedics of our institute.

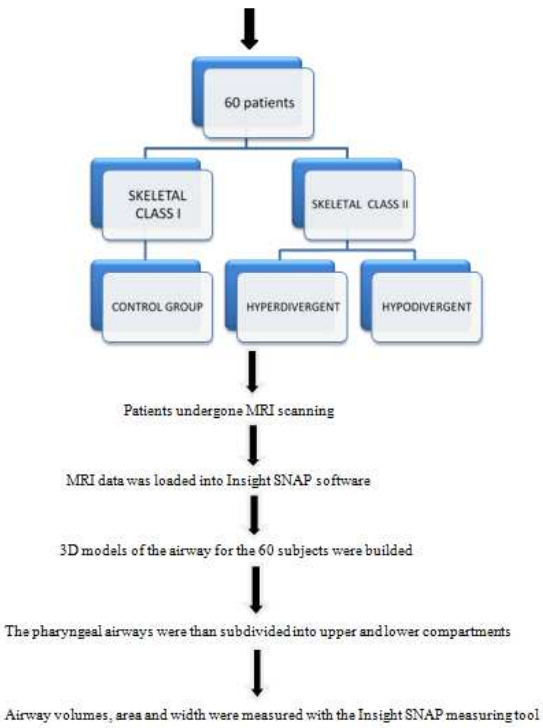


Figure 1: MRI Machine.

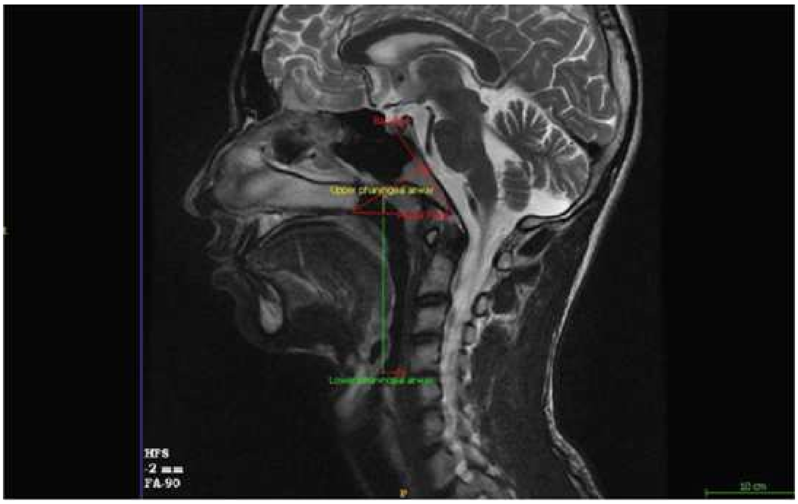


Figure 2: Landmarks of MRI.

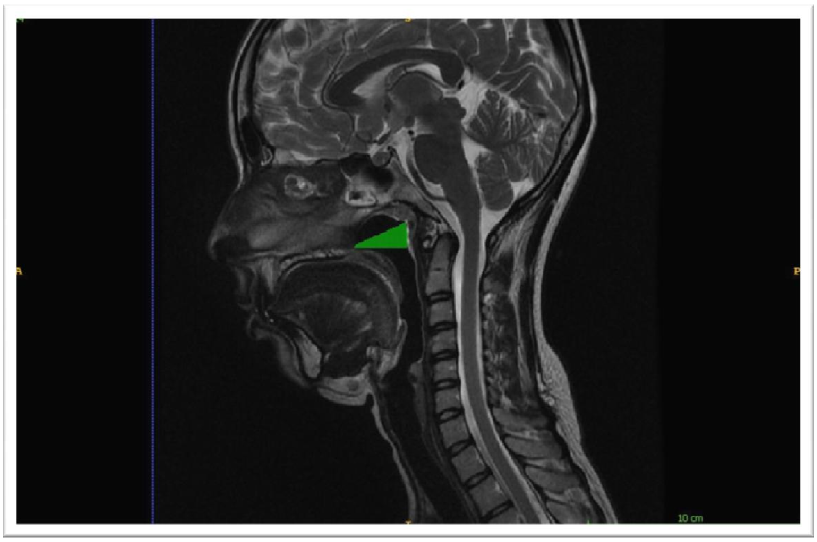


Figure 3: Measuring of Upper Pharyngeal Airway (Saggital View).

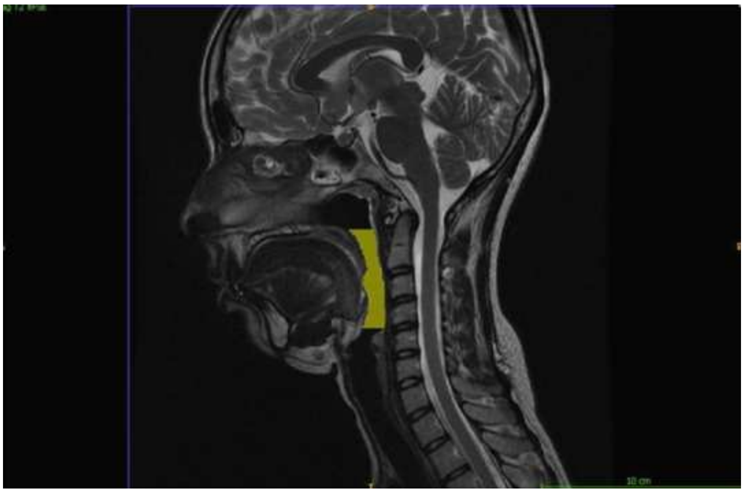


Figure 4: Measuring of Lower Pharyngeal Airway (Saggital View).

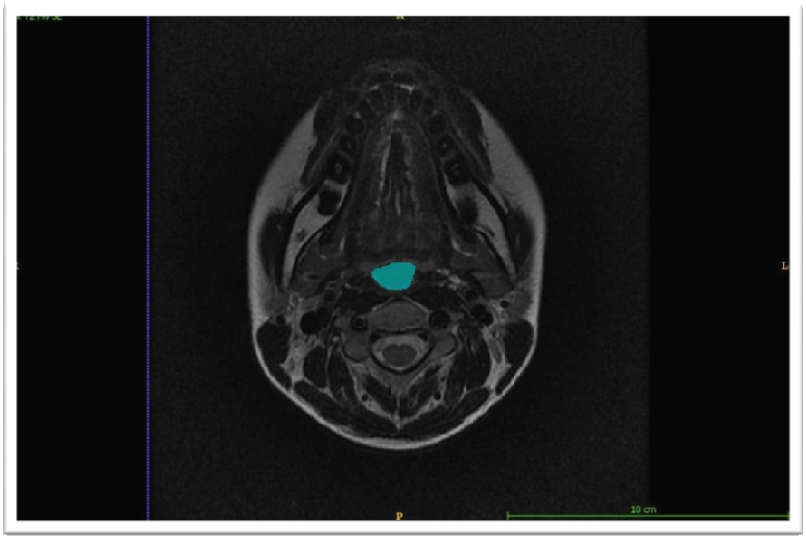


Figure 5: Measuring of Pharyngeal Airway (Axial View).

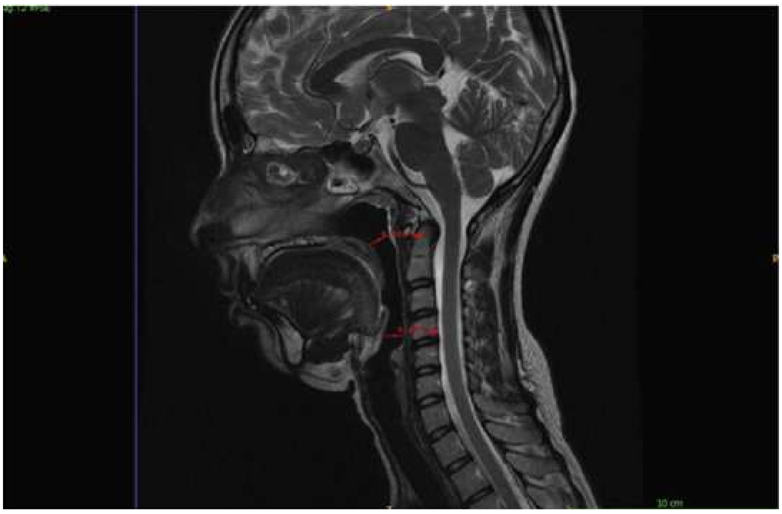


Figure 6: Upper and Lower Pharyngeal Airways Width.

Statistical Methods

SPSS for Windows, Version 16.0. Chicago, SPSS Inc software was used to analyse the data to evaluate and compare the upper and lower pharyngeal airway volume, width and area in skeletal Class I and Class II hypo-divergent and hyper-divergent skeletal pattern.

Statistical analysis was done by using tools of descriptive statistics such as Mean, and SD for representing quantitative data (e.g. volume, area, width of pharyngeal airway)

One-way ANOVA test was applied to compare measurements of means of three different malocclusion groups. Probability p & lt; 0.05, considered as significant as alpha error set at 5% with confidence interval of 95% set in the study. Power of the study was set at 80%with beta error set at 20%.

Post hoc data analysis which follows One way ANOVA was done by using Tukeys multiple comparison test was also used. Post hoc test analyses multiple pair –wise individual comparison at two different time interval each.

RESULTS

The aim of the present study was to assess a relationship between airway dimension in its volume, area and width according to the different cranio facial skeletal pattern morphologies of patients, both anteroposterior that is skeletal class I and II and vertical growth pattern.

The results showed that there is a significant relationship between airway volume, anteroposterior and vertical facial dimensions. In this study, the comparison of volumetric analysis of upper and lower pharyngeal airway in skeletal Class I (control group) and skeletal Class II hypo divergent and hyper divergent growth patterns was evaluated using Anova F test and found that there exist highly significant statistical difference ($p<0.001$) between groups.

Table 1(a): Comparison of Volumetric Analysis of Upper Pharyngeal Airway in Skeletal Class I (Control) and Class II with Different Growth Patterns

GROUPS	MEAN	Standard Deviation (S.D)	ANOVAF TEST	P value, Significance
CLASSI	8682.9	40.0		
(CONTROL)				
CLASSII(HYPODIVERGENT)	7575.3	29.24	F =13620.0	p <0.001, highly
CLASSII(HYPERDIVERGENT)	7109.4	20.58		significant

p>0.05 –not significantp <0.05 – significantp <0.001 – highly significant

On comparison of volumetric analysis of upper pharyngeal airway in skeletal class I with different vertical growth patterns using Anova F test, it was found that there exist highly significant statistical difference ($p <0.001$) between group**.**

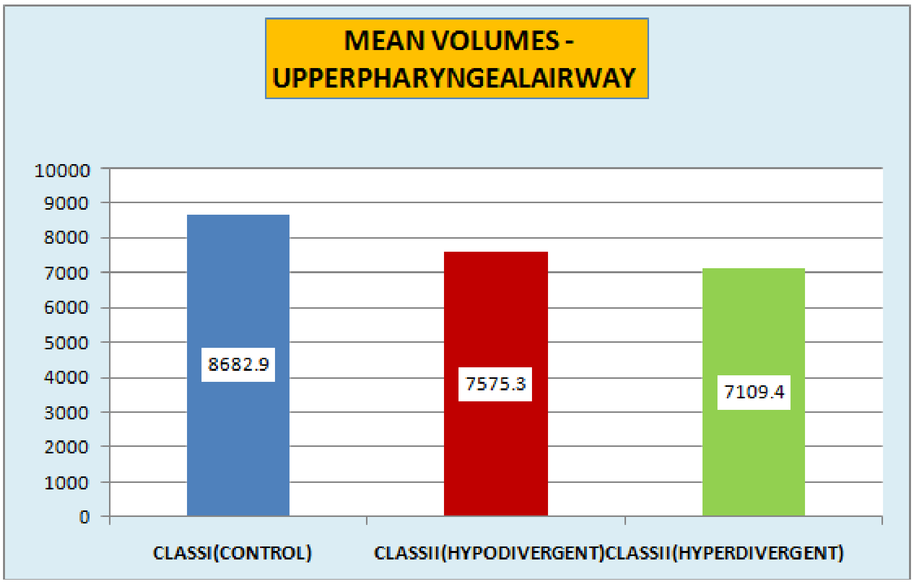
Table 1(b): Individual Pair Wise Comparison of Volumetric Analysis of Upper Pharyngeal Airway

Tukey's Post Hoc Test to Find Individual Pair Wise Comparison			
GROUP	**COMPARISONGROUP**	**MEANDIFFERENCE**	**p value, Significance**
CLASSI(CONTROL)	CLASSII(HYPODIVERGENT)	1107.6	p <0.001**
	CLASSII(HYPERDIVERGENT)	1573.5	p <0.001**
CLASSII(HYPODIVERGENT)	CLASSII(HYPERDIVERGENT)	465.92	p <0.001**

p>0.05 –not significant p <0.05 – significant p <0.001 – highly significant

On individual pair wise comparison of volumetric analysis of upper pharyngeal airway in skeletal class I with different vertical growth patterns using Tukey's post hoc test, it was found that there exist highly significant statistical difference (p< 0.001) between any two types of group.

Table 1 provided the value for volume of upper pharyngeal airway for skeletal Class I (control group) was 8682.9, for skeletal Class II hypo divergent it was 7575.3 with a standard deviation of 29.24 and for skeletal Class II hyper divergent it was 7109.4 with a standard deviation of 20.58. This concluded that skeletal Class II hyper divergent group has the lowest mean volume when compared with the skeletal Class II hypo divergent and the skeletal Class I.



Graph 1: Comparison of Volumetric Analysis of Upper Pharyngeal Airway in Skeletal Class I (Control) and Class II with Different Growth Patterns.

Table 2(a): Comparison of Volumetric Analysis of Lower Pharyngeal Airway in Skeletal Class I (Control) and Class II with different Growth Patterns

GROUPS	MEAN	Standard Deviation (S.D)	ANOVAFTEST	P value, Significance
CLASSI(CONTROL)	11694.4	15.10		
CLASSII(HYPODIVERGENT)	9771.9	24.23	F =52770.0	p <0.001, highly significant
CLASSII(HYPERDIVERGENT)	9617.4	26.58		

p>0.05 –not significant p <0.05– significant p <0.001 – highly significant

On comparison of volumetric analysis of lower pharyngeal airway in skeletal class I with different vertical growth patterns using Anova F test, it was found that there exist highly significant statistical difference (p <0.001) between group.

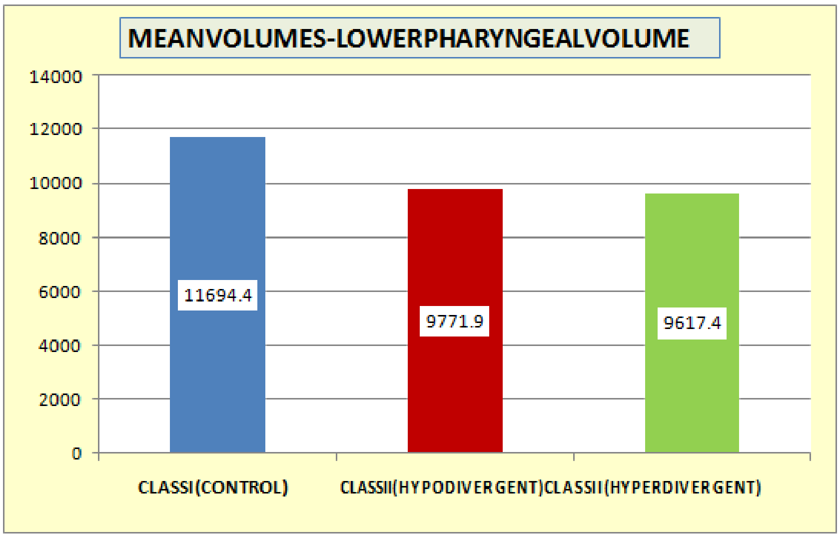
Table 2(b): Individual Pair Wise Comparison of Volumetric Analysis of Lower Pharyngeal Airway

Tukey's Post Hoc Test to Find Individual Pair Wise Comparison			
GROUP	**COMPARISONGROUP**	**MEAN DIFFERENCE**	**p value, Significance**
CLASSI(CONTROL)	CLASSII(HYPODIVERGENT)	1922.20	p <0.001**
	CLASSII(HYPERDIVERGENT)	2076.67	p <0.001**
CLASSII(HYPODIVERGENT)	CLASSII(HYPERDIVERGENT)	154.47	p <0.001**

p>0.05 –not significant p <0.05 – significant p <0.001 – highly significant

On individual pair wise comparison of volumetric analysis of lower pharyngeal airway in skeletal class I with different vertical growth patterns using Tukey's post Hoc test, it was found that there exist highly significant statistical difference ($p<0.001$) between any two types of group.

Table 2 provided the value for mean volume of lower pharyngeal airway for class I (Control group) was found to be 11694.4 with standard deviation of 15.10. For class II hypo divergent it was 9771.9 with a standard deviation of 24.23 & for Class II hyper divergent it was 9617.4 with a standard deviation of 26.58. The analysis resulted into a p value < 0.001, indicating statistically significant differences between the groups. It showed lowest mean volume in skeletal Class II hyper divergent group when compared with the skeletal Class II hypo divergent and the skeletal Class I.



Graph 2:Comparison of Volumetric Analysis of Lower Pharyngeal Airway in Skeletal Class I (Control) and Class II with different Growth Patterns.

Table 3(a): Comparative Analysis of Area of Pharyngeal Airway in Skeletal Class I (Control) and Class II with different Growth Patterns

GROUPS	MEAN	Standard Deviation (S.D)	ANOVA FTEST	P value, Significance
CLASSI(CONTROL)	151.69	3.09	F=1590.0	p <0.001, highly significant
CLASSII(HYPODIVERGENT)	110.05	4.90		
CLASSII(HYPERDIVERGENT)	79.82	3.94		

p>0.05 –not significant p <0.05 – significant p <0.001 – highly significant

On comparison of volumetric analysis related to area of pharyngeal airway in skeletal class I with different vertical growth patterns using Anova F test, it was found that there exist highly significant statistical difference ($p<0.001$) between group.

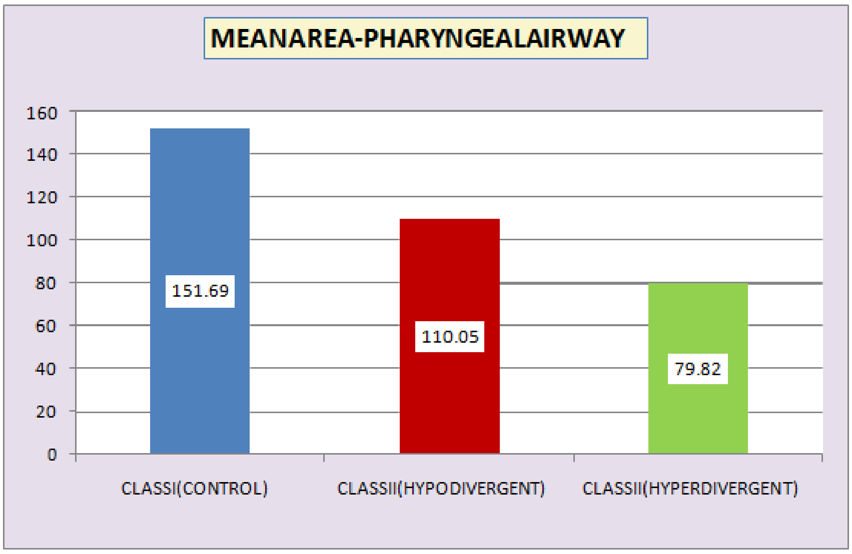
Table 3(b): Individual Pair Wise Comparison Related to Area of Pharyngeal Airway

Tukey's Post Hoc Test to Find Individual Pair Wise Comparison			
GROUP	**COMPARISONGROUP**	**MEAN DIFFERENCE**	**p value, Significance**
CLASSI(CONTROL)	CLASSII(HYPODIVERGENT)	41.64	p <0.001**
	CLASSII(HYPERDIVERGENT)	71.87	p <0.001**
CLASSII(HYPODIVERGENT)	CLASSII(HYPERDIVERGENT)	30.23	p <0.001**

p>0.05 –not significant p <0.05 – significant p <0.001 – highly significant

On individual pair wise comparison of volumetric analysis related to area of pharyngeal airway in skeletal class I with different vertical growth patterns using Tukey's post hoc test, it was found that there exist highly significant statistical difference (p <0.001)between any two types of group.

Table 3 provided the value for mean area of pharyngeal airway for Class I (Control group) was found to be 151.69 with standard deviation of 3.09. For Class II hypo divergent it was 110.05 with astandard deviation of 4.90 & for Class II hyper divergent it was 79.82 with a standard deviation of 3.94. The analysis resulted into a p value < 0.001, indicating statistically significant differences between the groups. It showed lowest mean area in skeletal Class II hyper divergent group when compared with the skeletal Class II hypo divergent and the skeletal Class I.



Graph 3: Comparison of Mean Area of Pharyngeal Airway in Skeletal Class I (Control) and Class II with different Growth Patterns.

Table 4(a): Comparative Analysis of Width of Upper Pharyngeal Airway in Skeletal Class I (Control) and Class II with different Growth Patterns

GROUPS	MEAN	Standard Deviation (S.D)	ANOVA F TEST	P value, Significance
CLASSI(CONTROL)	15.80	0.82	F=227.84	p <0.001, highly significant
CLASSII(HYPODIVERGENT)	13.66	0.49		
CLASSII(HYPERDIVERGENT)	11.33	0.62		

p>0.05 –not significant p <0.05 – significant p <0.001 – highly significant

On comparison of volumetric analysis of width of upper pharyngeal airway in skeletal class I with different vertical growth patterns using Anova F test, it was found that there exist highly significant statistical difference (p <0.001) between group.

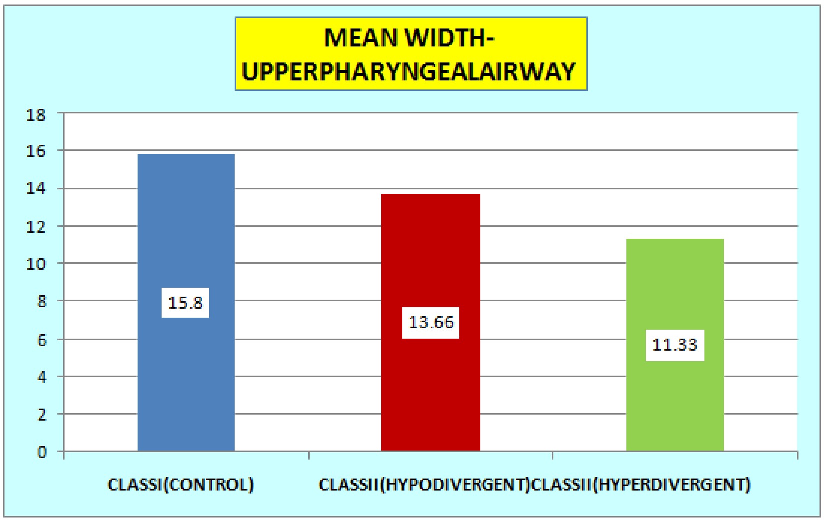
Table 4(b): Individual Pair Wise Comparison Related to Width of Upper Pharyngeal Airway

Tukey's Post HOC Test to Find Individual Pair Wise Comparison			
GROUP	**COMPARISONGROUP**	**MEANDIFFERENCE**	**p value, Significance**
CLASSI(CONTROL)	CLASSII(HYPODIVERGENT)	2.13	p <0.001**
	CLASSII(HYPERDIVERGENT)	4.46	p <0.001**
CLASSII(HYPODIVERGENT)	CLASSII(HYPERDIVERGENT)	2.33	p <0.001**

p>0.05 –not significant p <0.05 – significant p <0.001 – highly significant

On individual pair wise comparison of volumetric analysis of width of upper pharyngeal airway in skeletal class I with different vertical growth patterns using Tukey's post hoc test, it was found that there exist highly significant statistical difference (p<0.001)between any two types of group.

Table 4 provided the mean width of upper pharyngeal airway for class I (Control group) was found to be 15.80 with standard deviation of 0.82. For Class II hypo divergent, it was 13.66 with a standard deviation of 0.49 & for Class II hyper divergent, it was 11.33 with a standard deviation of 0.62. The difference of mean volume was statistically evaluated using Anova F test. The analysis resulted into a p value < 0.001, indicating statistically significant differences between the groups. It showed lowest mean width in skeletal Class II hyper divergent group when compared with the skeletal Class II hypo divergent and the skeletal Class I.



Graph 4: Comparison of Mean Width of Upper Pharyngeal Airway in Skeletal Class I (Control) and Class II with different Growth Patterns.

Table 5(a): Comparative Analysis of Width of Lower Pharyngeal Airway in Skeletal Class I (Control) and Class II with different Growth Patterns

GROUPS	MEAN	Standard Deviation (S.D)	ANOVA F TEST	P value, Significance
CLASSI(CONTROL)	11.61	0.53	F=597.94	p <0.001, highly significant
CLASSII(HYPODIVERGENT)	8.21	0.35		
CLASSII(HYPERDIVERGENT)	6.47	0.51		

p>0.05 –not significant p <0.05 – significant p <0.001 – highly significant

On comparison of volumetric analysis of width of lower pharyngeal airway in skeletal class I with different vertical growth patterns using Anova F test, it was found that there exist highly significant statistical difference (p <0.001) between group.

Table 5(b): Individual Pair Wise Comparison Related to Width of Lower Pharyngeal Airway

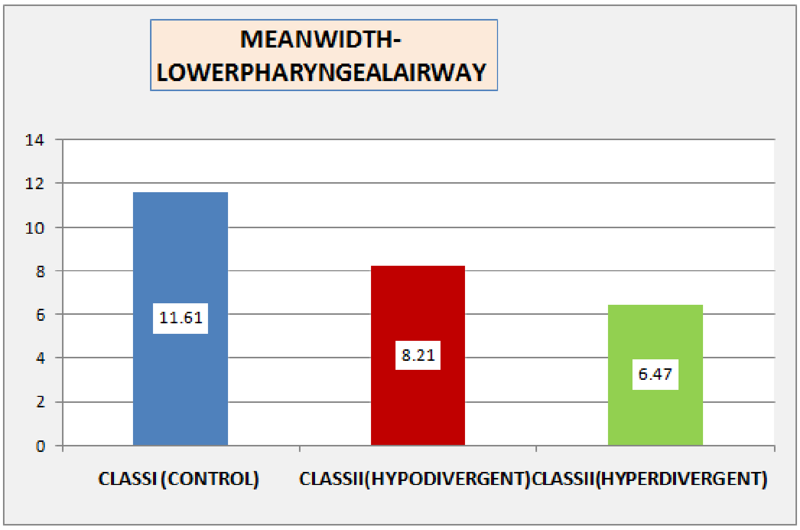
Tukey's Post HOC Test to Find Individual Pair Wise Comparison			
GROUP	**COMPARISON GROUP**	**MEAN DIFFERENCE**	**p value, Significance**
CLASSI(CONTROL)	CLASSII(HYPODIVERGENT)	3.4	p <0.001**
	CLASSII(HYPERDIVERGENT)	5.14	p <0.001**
CLASSII(HYPODIVERGENT)	CLASSII(HYPERDIVERGENT)	1.73	p <0.001**

p>0.05 –not significant p <0.05 – significant p <0.001 – highly significant

On individual pair wise comparison of volumetric analysis of width of lower pharyngeal airway in skeletal class I with different vertical growth patterns using

Tukey's post hoc test, it was found that there exist highly significant statistical difference (p <0.001) between any two types of group.

Table 5 provided the mean width of lower pharyngeal airway for Class I (Control group) was found to be 11.61 with standard deviation of 0.53. For Class II hypo divergent, it was 8.21 with a standard deviation of 0.35 & for class II hyper divergent, it was 6.47 with a standard deviation of 0.51. The difference of mean volume was statistically evaluated using Anova F test. The analysis resulted into a p value < 0.001, indicating statistically significant differences between the groups. It showed lowest mean width in skeletal Class II hyper divergent group when compared with the skeletal Class II hypo divergent and the skeletal Class I.



Graph 5: Comparison of Mean Width of Lower Pharyngeal Airway in Skeletal Class I (Control) and Class II with different Growth Patterns.

DISCUSSION

The relationship between pharyngeal dimensions and the dento facial pattern in OSA patients has been of interest to orthodontists. Numerous studies have reported on the relevance of pharyngeal dimensions to various sagittal and vertical facial growth pattern sat varying degrees [73,74] like hyper divergent patients with certain skeletal features, such as retrusive mandible and vertical maxillary excess, may have narrower anterioposterior airway dimensions [30]. Thus, knowledge of pharyngeal dimensions amongst the sagittal and vertical facial types is of great importance for orthodontist, especially for orthodontic diagnosis and treatment planning.

Solow and Sandham et al (2002) [75] showed that the craniocervical angle is relatively small in subjects with mandible prognathism and large in subjects with mandible retrognathism. They hypothesized that a change in head posture affects the cranio cervical angle and the position of the jaw and tongue. A postural change such as head extension causes a down-backward rotation of the mandible which leads to stretching of the lips, cheeks, and musculature and affects malocclusion and growth pattern. Then, the airway is opened and stabilized as necessary to compensate for the reduced respiratory function caused by the constricted airway and to maintain the airway.

During last decades, numerous ways have been used for airway assessing[76-80]. At first, airway measurement was performed on the lateral cephalo grams by linear measurement. But this method had severe limitations such as using 2-Drepresentations of 3-D structures, differences in magnifications, super imposition of bilateral cranio facial structures, and low reducibility due to difficulties in landmark identification[81]. New3-Dimaging approaches including CBCT have become efficient modalities for airway assessments as its images have negligible magnification with a 1:1 ratio in all three planes of space[82]. However, it exposes patients to radiation and poor contrast resolution; magnetic resonance imaging (MRI)[83]has been introduced which can characterize and discriminate among tissues using their physical and biochemical properties and produces sectional images of equival entre solution in any projection which add stoitsvers atility and diagnostic utility and does not use ionizing radiation.

In this study, MRI was performed with the patient in an supine position. In the supine position, there is a decrease or opharyngeal airway whereas the thickness of both the tongue and soft palate increases due to either gravitational force or changes in upper airway reflexes, which may predispose to increased collapsibility of the upper airway[83]. The nasopharynxis surrounded by bony structures, whereas the oropharyngeal airway is surrounded by soft tissues, which probably explains why the oropharynxis more predisposed to external factors such as posture. Asupine MRI thus provides more physiologic information since it is obtained in the usual sleeping posture.

The age of the individuals taken for the study were from 16-30years, so all measurements performed on them were taken with the airway growth complete, as previously described by(Shengetal, 2009)[84].

The aim of the present study was to assess a relationship between airway dimension in its volume, area and width according to the different cranio facial skeletal pattern morphologies of patients, both anteroposterior that is skeletal class I and II and vertical growth pattern.

In this study, the results showed that there is a significant relationship between airway volume, anteroposterior and vertical facial dimensions. The comparison of volumetric analysis of upper and lower pharyngeal airway in skeletal Class I (control group) and skeletal Class II hypo divergent and hyper divergent growth patterns was evaluated using Anova F test and was found that there exist highly significant statistical difference ($p<0.001$ between groups.

In this study, the value found for volume of upper pharyngeal airway in skeletal Class I (control group) was 8682.9, in skeletal Class II hypo divergent it was 7575.3 with a standard deviation of 29.24 and in skeletal Class II hyper divergent it was 7109.4 with a standard deviation of 20.58. This concluded that skeletal Class II hyper divergent group has the lowest mean volume when compared with the skeletal Class II hypo divergent and the skeletal Class I.

When the mean volume of upper pharyngeal airway of skeletal Class I control group was compared with the skeletal Class II hypo divergent, the mean difference was 1107.6, which was found to be highly significant with p value <0.001. So, there was reduced mean volume in skeletal Class II hypo divergent when compared with skeletal Class I. Similarly, when skeletal Class I control group was compared with the Class II hyper divergent, the mean difference was 1573.5, which showed reduced airway volume in skeletal Class II hyper divergent. When skeletal class II hypo divergent was compared with the skeletal Class II hyper divergent, the mean difference of the group was 465.92, which showed reduced airway volume in skeletal Class II hyper divergent.

Josephetal[30] reported that the nasopharyngeal airway in hyper divergent individuals was significantly narrower than normo divergent individuals. However, they suggested that this difference occurred because of the relative bimaxillaryretrusion exhibited by the hyper divergent group. Their conclusions were similar to those of the present study where smaller nasopharyngeal airway space was found in high angle subjects when compared with low angle and normal growth subjects.

MG Lenza (2010)[45] et al performed a 3D evaluation of the upper airway and showed similar result with high correlations between sagittal, transversal, and cross-sectional area with reduced volume in nasopharynxin skeletal Class II.

Kim et al (2010)[44] assessed pharyngeal volume and cross-sectional areas with CBCT in 27 children. They reported that total pharyngeal volume (nasalcavity, nasopharynx and oropharynx) inretrognathic children were significantly smaller than those with a normal skeletal pattern. They also noted that pharyngeal volumetric measurements significantly correlated with the ANB angle and anterior facial height.

Ucaret al (2011)[46] studied on Class I subjects with different vertical growth patterns. They reported larger nasopharyngeal airway space in low angle subjects than in high angle subjects. Also, when the cranio facial skeleton was assessed it demonstrated reduced SNA, SNB, and posterior facial height this can be attributed to the fact that there is decrease in dimensions of the superior part of the upper airway in high angle subjects.

The mean volume of lower pharyngeal airway in Class I (Control group) was found to be 11694.4 with standard deviation of 15.10, in Class II hypo divergent it was9771.9 with a standard deviation of 24.23 & in Class II hyper divergent it was 9617.4 with a standard deviation of 26.58. The analysis resulted into a p value < 0.001, indicating statistically significant differences between the groups. It showed lowest mean volume in skeletal Class II hyper divergent group when compared with the skeletal Class II hypo divergent and the skeletal Class I. The highest mean volume was seen in skeletal Class I.

When the mean volume of lower pharyngeal airway of skeletal Class I control group was compared with the skeletal Class II hypo divergent, the mean difference was 1922.20, which was found to be highly significant with p value <0.001. So, there was reduced mean volume in skeletal Class II hypo divergent when compared with skeletal Class I. Similarly, when skeletal Class I control group was compared with the Class II hyper divergent, the mean difference was 2076.67, which showed reduced airway volume in skeletal Class II hyper divergent. When skeletal class II hypo divergent was compared with the skeletal Class II hyper divergent, the mean difference of the group was 154.47, which showed reduced airway volume in skeletal Class II hyper divergent.

Similar result was found in other study, Graueretal (2009)[42] observed differences in airway volume and shape according to different maxillary relationships. They analyzed the total pharyngeal volume in 62 CBCT scans after classifying them into Class I, II and III skeletal patterns. They also divided the same sample into long, short and normal face types based on the facial index. The pharyngeal volume did not correlate with the subject’s age or gender. The volume of Class II subjects in the inferior compartment was significantly smaller, but it did not statistically differ among the short, normal and long face types.

Zhong et al (2010)[85] showed that the vertical and sagittal skeletal patterns could contribute to the variation of the airway dimensions.

El and Palomo(2011) [86]using a sample of adolescents between 14–17 years reported that Class II subjects had a significantly lower oropharyngeal volume than Class I and Class III subjects. These volumes were significantly smaller in individuals with retruded mandibles than those with a high SNB angle. The most constricted region of the oropharynx was located at the level of the tongue base.

Alves et al(2012)[87] found that patients with deficient mandibular growth had alower airway volume. Although them andible has both retruded and rotated in downward and backward directions, the tongue base might be positioned more posteriorly and inferiorly; thus, the oropharyngeal airway space may have decreased.

Claudino et al(2015)[51] stated that Class II subjects had smaller volume and minimum and mean areas (lower pharyngeal portion, velopharynx, and oropharynx)than the Class III group. Oh et al(2011)[47] found similar results, since children with Class II malocclusion had more backward orientation and smaller volume of the pharyngeal airway than children with Class I and III malocclusion.

The mean area of pharyngeal airway in Class I (Control group) was found to be 151.69 with standard deviation of 3.09. In Class II hypo divergent it was 110.05with a standard deviation of 4.90 & in Class II hyper divergent it was 79.82 with a standard deviation of 3.94. The analysis resulted into a p value < 0.001, indicating statistically significant differences between the groups. It showed lowest mean area in skeletal Class II hyper divergent group when compared with the skeletal Class II hypo divergentand the skeletal Class I.

Kerr[88] investigated the relationship between the nasopharyngeal and dento facial structures on the subjects with normal and Class II malocclusions and found that the subjects with Class II malocclusion had a larger nasopharyngeal airway area than the subjects with normal occlusions.

Ceylan and Oktay[4] found that changes in the ANB angle may affect theoropharyngeal space which was reduced in subjects with an increased ANB angle. This can be explained with the Balters philosophy [89] which states that Class II malocclusions have the following predisposing factors such as backward position of the tongue that disturbs the cervical region which in turn reduces the airway dimension, whereas Class III malocclusions are due to forward positioning of the tongue and result in greater airway dimensions.

Joseph et al [30] reported that are tro positioned maxilla can lead to a narrowing of the nasopharynx and oropharynx. This feature is compounded by a more horizontal angulation of the soft palatein the hyper divergent group, which reduces the anteropoterior dimension of this region of the airway.

Ucar and Uysal [46] reported a significant difference between low angle and high angle in Class I group sat the level of the nasopharyngeal airway space. The nasopharyngeal airway space decreased from low-angle to normal to high-angle cases and highlighted the effect of the vertical pattern on upper airway space.

The mean width of upper pharyngeal airway in Class I (Control group) was found to be 15.80 with standard deviation of 0.82. In Class II hypo divergent, it was 13.66 with a standard deviation of 0.49 & in Class II hyper divergent, it was 11.33 with a standard deviation of 0.62. The difference of mean volume was statistically evaluated using Anova F test. The analysis resulted into a p value < 0.001, indicating statistically significant differences between the groups. It showed lowest mean width in skeletal Class II hyper divergent group when compared with the skeletal Class II hypo divergent and the skeletal Class I.

The mean width of lower pharyngeal airway in Class I (Control group) was found to be 11.61 with standard deviation of 0.53. In Class II hypo divergent, it was 8.21 with a standard deviation of 0.35 & in Class II hyper divergent, it was 6.47 with a standard deviation of 0.51. The difference of mean volume was statistically evaluated using Anova F test. The analysis resulted into a p value < 0.001, indicating statistically significant differences between the groups. It showed lowest mean width in skeletal Class II hyper divergent group when compared with the skeletal Class II hypo divergent and the skeletal Class I.

Similar result was found where Josephetal[30] reported that decrease in oropharyngeal width may be due to the posterior vertical maxillary excess which is common to hyper divergent patients. The resultant rotated mandible causes the base of the tongue to be positioned more posteriorly and inferiorly.

Opdebeeck and Bell[90] in a comparative study of short and long face individuals concluded that a short ramus in the long face syndrome might beac companied by a decreased cross section of the lower pharynx.

Akcamet al[34]reported a decrease in the upper airway dimensions of subjects who had posterior mandibular rotation. This reveals a close association between the pharyngeal airway and jaw position.

Juhi Ansar[91] etal found that Subjects with vertical growth patterns have significantly narrower upper and lower pharyngeal airways than those with Class II malocclusions and horizontal and normal growth patterns. These patients may be more prone to mouth breathing as a result of their relatively diminished pharyngeal dimension.

Increased nasopharyngeal linear widths in brachy facial pattern, in comparison to other vertical facial patterns, might be the result of a deficient anteroposterior development of the craniomaxillary complex in brachy facial pattern. Facial growth changes may also be related to differences in the direction of condylar growth, and may result from differences in development of anterior facial height and posterior facial height[68]. These differences in vertical development may lead to rotational growth orpositional changes of them and ible, which could affect the airway dimensions. This resulted that the mandibular positional changes are more likely to affect the oropharynx than the nasopharynx.

These finding of present study led to the conclusion that Class II subjects are more susceptible to the development of obstructive sleep apneasyn drome than patients with other skeletal patterns.

So, Orthodontists must be aware of the risk factors pertaining to reduced airway and should define an appropriate treatment plan by not compromising on the airway dimensions especially on patients who are prone to it[92]. Airway analysis should be a part of diagnosis and treatment planning especially in patients prone to reduced airway like skeletal Class II pattern so that the risk of developing OSA in these patients can be minimized. Correcting early Class II using functional appliances can help in reducing the chances of airway problems in future.

Longitudinal studies of airway changes in subjects with different skeletal patterns in specific craniofacial growth and development periods should be performed to know the detailed knowledge of the relationship between upper airway morphology and function and craniomaxillo facial characteristics.

LIMITATION

- Limitation of present study is the lack of control group due to ethical issues, relatively high cost, as well as the limited availability of MRI technique.
- MRI images were obtained when patients were awake and there is no way to find out whether their tongue was in the standard position as patients were in supine position.
- In order to find the relationship of structural information with function, it would be ideal if these MRI findings would have been correlated with the findings of polysomnography. Due to cost considerations and the fact that polysomno graphy requires overnight hospital admission this was not feasible.

SUMMARY

The nasopharynx and the oropharynx have a significant locations and functions because both of them form a part of the unit in which respiration and deglutition are carried out. A significant relationship exists between the pharynx and Dento facial and skeletal structures. The nasopharyngeal airway has been claimed to affect the growth of craniofacial structures. It is also established that the posture of the tongue can also influence the dental relationship and facial skeletal pattern of an individual and vice versa can also happen.

Hence, the present study was carried out to evaluate pharyngeal airway dimensions and compare the volumetric analysis of pharyngeal airway in skeletal class I and II individuals with different vertical growth patterns. A total of 60 patients between the age group of 16 to 30 years having skeletal Class I, Class II hypo divergent and Class II hyper divergent growth pattern were selected from those visiting the Department of Orthodontics and Dento facial Orthopaedicso four institute.

Studies were performed using a 1.5 Tesla magnetic resonance imaging scanner and the MRI data were loaded in the software for 3D models of airway which were analysed. Following observations were seen–

- Lowest mean volume, area and width of upper and lower pharyngeal airway in skeletal Class II hyper divergent group when compared with the skeletal Class II hypo divergent and the skeletal Class I.
- This is due to the retruded mandible and downward and backward directions of mandible which resulted posterior and inferior position of the tongue base.

CONCLUSION

The findings for the study lead to following conclusion–

- There is a significant relationship between airway volume, anteroposterior and vertical facial dimensions.
- Lowest mean volume and width of upper and lower pharyngeal airway in skeletal Class II hyper divergent group was seen when compared with the skeletal Class II hypo divergent and the skeletal Class I.
- The highest mean area was seen in skeletal Class I group followed by skeletal Class II hypo divergent and lowest seen in skeletal Class II hypo divergent.

BIBLIOGRAPHY

1. *Faye Dunn GW, Green LJ, Cunat JJ. Relationships between variation of mandibularmorphology and variation of nasopharyngeal airway size in monozygotic twins. The Angle Orthodontist.1973 Apr; 43(2): 129-35.*
2. *Harvold EP. Neuromuscular and morphological adaptations in experimentally induced oral respiration. In Nasorespiratory function and craniofacial growth 1979 (pp. 149-164). University of Michigan, Ann Arbor.*
3. *De Freitas MR, Alcazar NM, Janson G, de Freitas KM, Henriques JF. Upper and lower pharyngeal airways in subjects with Class I and Class II malocclusions and different growth patterns. American journal of orthodontics and dentofacial orthopedics. 2006 Dec1;130(6):742-5.*
4. *Ceylan I, Oktay H. A study on the pharyngeal size in different skeletal patterns. American Journal of Orthodontics and Dentofacial Orthopedics. 1995 Jul 1; 108(1):69-75.*
5. *Lampasso, Judith D, Lampasso, James G. Allergy, nasalobstruction, and occlusion. Semin Orthod. 2004;10:39–44.*
6. *Weissheimer A, deMenezes LM, Sameshima GT, Enciso R, Pham J, Grauer D.Imaging software accuracy for 3-dimensional analysis of the upper airway. AmJ Orthod Dentofacial Orthop 2012; 142: 801-13.*
7. *Ogura M, Higano S, Hida W, Ikeda K, Oshima T, Takahashi S, Matsuoka H, Suzuki H, Kurosawa H, Takasaka T. Quantitative assessment of the pharyngeal airway by dynamic magnetic resonance imaging in obstructive sleep apnea syndrome. Annals of Otology, Rhinology & Laryngology. 2001 Feb1; 110(2):183-9.*
8. *Cheung T, Oberoi S. Three dimensional assessment of the pharyngeal airway in individuals with non-syndromic cleftlip and palate. PLoS One 2012; 7: e43405.*
9. *Kirby M, Svenningsen S, Kanhere N, Owrangi A, Wheatley A, Coxson HO, etal. Pulmonary ventilation visualized using hyperpolarizedhelium-3 and xenon-129 magnetic resonance imaging: differences in COPD and relationship to emphysema. JApplPhysiol2012; 114:707-15.*
10. *Morrison WW. The inter relationship between nasal obstruction and oraldeformities: The action of obstructed nasal breathing upon the mouth and the facial structures; an historical review. International Journal of Orthodontia, Oral Surgery and Radiography. 1931 May1; 17(5):453-8.*