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INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/13544
DOI URL: <http://dx.doi.org/10.21474/IJAR01/13544>



RESEARCH ARTICLE

RELATION BETWEEN SAGITTAL POSITION OF THE MANDIBLE AND PHARYNGEAL AIRWAY VOLUME IN ADULTS USING CONE BEAM COMPUTED TOMOGRAPHY

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Manuscript Info

Manuscript History

Received: 15 August 2021

Final Accepted: 18 September 2021

Published: October 2021

Key words:-

Cone Beam Computed Tomography,
Mandible, Pharyngeal Airway

Abstract

Introduction: Many authors have discussed the relationship between craniofacial morphology and pharyngeal airway spaces in different malocclusions and skeletal patterns. So the aim of this work was to study the relation between sagittal position of the mandible and pharyngeal airway volume in adults using CBCT.

Materials And Methods: Twentyone CBCT radiographs were collected from the archive of Radiology Department at Suez Canal University and were divided into 3 groups according to the measured SNB angle. Group 1 normal mandibular position, group 2 retrognathic mandible and group 3 prognathic mandible. Dolphin 3D imaging software was used to measure the airway volume for all the radiographs. Nasopharyngeal, oropharyngeal, hypopharyngeal and total pharyngeal airway volumes were measured for all the radiographs. F-test (ANOVA) was used for comparison between groups and Tukey test for pairwise comparisons. Correlations between variables were tested using Pearson's correlation coefficient.

Results: there was statistically significant difference in the mean total pharyngeal airway volume and oropharyngeal airway volumes between the three groups. Nasopharyngeal airway volume and hypopharyngeal airway volume had non-significant difference between groups. There was a significant positive correlation between total pharyngeal airway volume (mm³) and SNB angle.

Conclusion: Pharyngeal airway volume differs with different sagittal positions of the mandible. Pharyngeal airway volume decreases with mandibular retrognathism and increases with mandibular prognathism.

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Introduction:-

The relationship between craniofacial morphology and respiratory function has been under investigation since the late 19th century. Many authors have discussed the relationship between craniofacial morphology and pharyngeal airway spaces in different malocclusions and skeletal patterns(Kula, k. et al., 2013).

Many reports have demonstrated a relationship between various malocclusion patterns and the size and form variabilities of the pharyngeal airway. The airway has been assessed with various imaging techniques as

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Fluoroscopy, Cephalometry, Cone Beam Computed Tomography (CBCT) and Magnetic Resonance Imaging (MRI)(Soni, J. et al., 2015).

CBCT system provides more reliable landmark identification of the anatomical structures than two-dimensional imaging and allows precise measurements and better visualization of the airway(Kula, k. et al., 2013).

Some authors reported that pharyngeal airway volume was greater in skeletal Class III patients than in Class I and Class II patients. Others reported that there is no significant difference between pharyngeal airway and different dento-skeletal classifications(Kula, k. et al., 2013). Hence, the aim of this study is to study the relation between sagittal position of the mandible and pharyngeal airway volume in adults using CBCT.

Materials and Methods:-

CBCT scans were collected from the archive of the Radiology Department, Faculty of Dentistry at Suez Canal University. The study was approved by the Research Ethics Committee of Suez Canal University.

All CBCT scans were taken using Soredex SCANORA 3D present in the Radiology department, Suez Canal University.

All obtained images were imported into DICOM (Digital Imaging and Communications in Medicine) format and handled by Dolphin Imaging Software.

Head 3D reconstructions of each radiograph were reoriented according to three reference planes: Sagittal, Axial and Coronal planes.

The Mid-sagittal plane matched the skeletal midline by passing through the Nasion and anterior nasal spine.

The axial plane was made to match the Frankfort Horizontal plane where it passed through the inferior points of the lower contour of the right and left orbits together with the right Porion.



Fig.1:- Reference planes.

Once the skull was oriented according to the reference planes, the software was used to measure the SNB angle. The mid sagittal view was opened and manual digitization for the anatomical landmarks was done. The points S, N and point B were identified and the angle SNB was measured automatically.



Fig.2:- Automatic measurement of SNB angle.

Grouping

The CBCT radiographs were divided into 3 equal groups according to the measured SNB angle into:

1. **Group 1:** normal mandibular position with $76^{\circ} \leq \text{SNB} \leq 80^{\circ}$.
2. **Group 2:** retro-gnathic mandible with $\text{SNB} < 76^{\circ}$.
3. **Group 3:** pro-gnathic mandible with $\text{SNB} > 80^{\circ}$.

Measurement of pharyngeal airway volume

For analysis of pharyngeal airway volume, the following landmarks have been identified:

1. The anterior nasal spine(ANS) and posterior nasal spine(PNS) were identified and the palatal plane was drawn.
2. The inferior border of the pharyngeal airway space at the level of epiglottis base was drawn parallel to the palatal plane.
3. Two points at the level of epiglottis tip were plotted and adjusted to be parallel to the palatal plane.
4. The superior border of the oropharynx was dragged till reaching the Sella point.

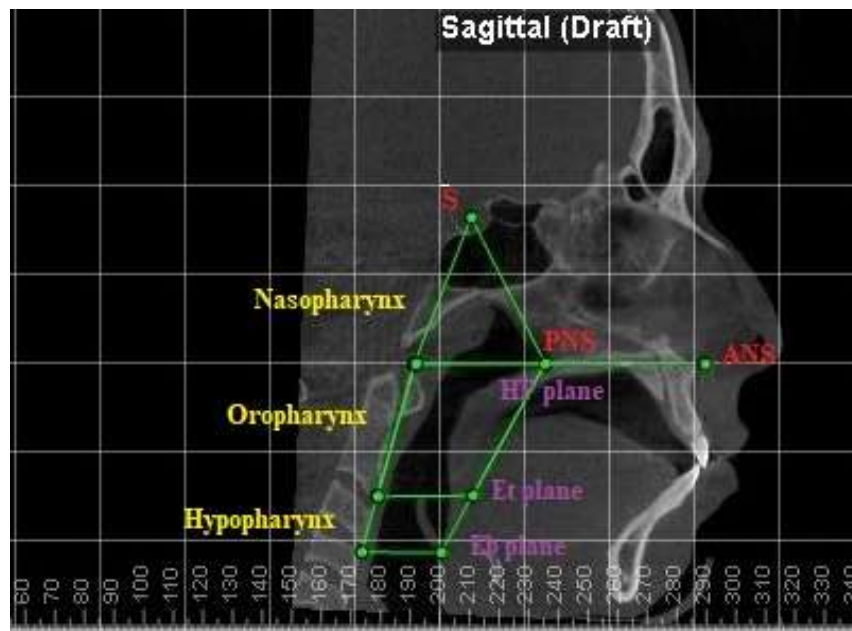


Fig. 3:-Pharyngeal airway boundaries and divisions.

S: Sella, ANS: anterior nasal spine, PNS: posterior nasal spine, HP plane: hard palate plane, Et plane: tip of epiglottis plane, Eb plane: base of epiglottis plane.

Boundaries and divisions of the pharyngeal airway (Chen, X. et al., 2015 & Irani S.K. et al., 2018):

Nasopharynx

The top of the upper airway to hard palate plane.

1. Anterior: The posterior soft palate.
2. Posterior: The posterior pharyngeal wall.
3. Superior: Sella.
4. Inferior: Hard palate plane.

Oropharynx

The hard palate plane to the superior border of the epiglottis.

1. Anterior: The posterior soft palate and base of the tongue.
2. Posterior: The posterior pharyngeal wall.
3. Superior: The hard palate plane.
4. Inferior: The superior border of epiglottis.

Hypopharynx

The superior border of the epiglottis to the bottom of the epiglottis.

1. Anterior: the base of the tongue.
2. Posterior: The posterior pharyngeal wall.
3. Superior: The superior border of epiglottis.
4. Inferior: The base of epiglottis.

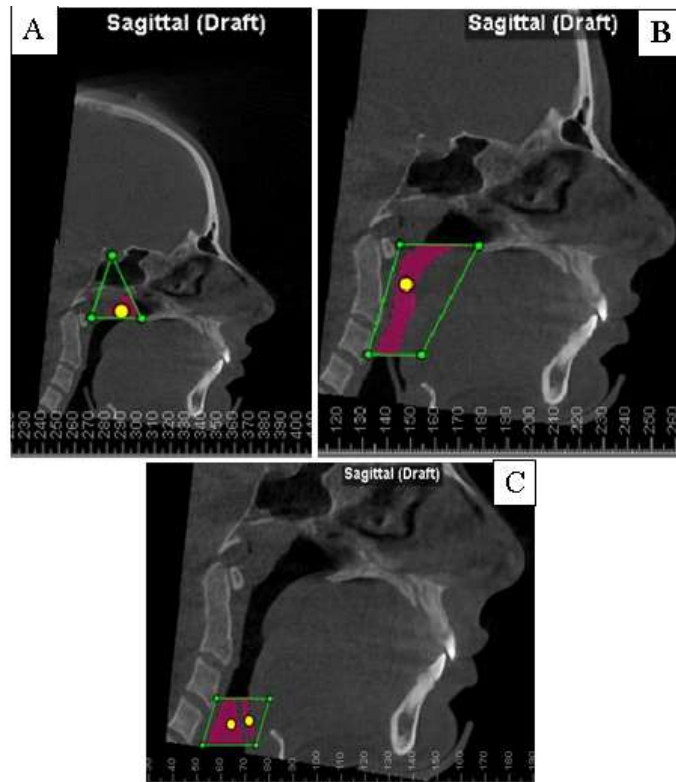


Fig. 4:- Segmented pharyngeal airway volume measurement.

After marking these points and joining them together, using the Sinus/Airway tool, a yellow marker (seed point) was placed within the selected boundary of the airway. The threshold value was adjusted manually between 50 to 55 for all individuals.

The total pharyngeal airway volume was measured automatically and checked in axial, coronal and sagittal planes. The slider was used to check that there is no gaps or overfills of the pharyngeal airway space. Then, the nasopharynx, oropharynx and hypopharynx were measured separately with the same reference points and planes mentioned before and their volumes were calculated automatically.

All measurements were repeated again with two weeks interval by the same operator.

Statistical Analysis of the Data

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level.

The used Tests Were

F-test (ANOVA)

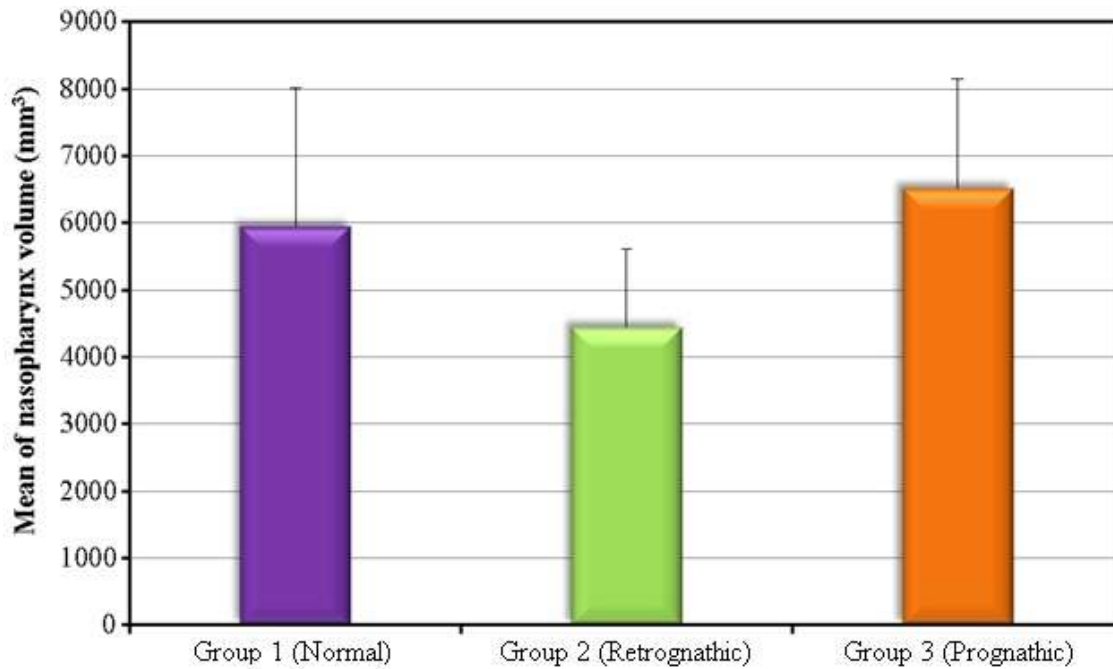
For normally distributed quantitative variables, to compare between more than two groups, and Post Hoc test (Tukey) for pairwise comparisons.

Pearson Coefficient

To correlate between two normally distributed quantitative variables.

Results:-

There was a statistically non-significant difference in the mean of nasopharyngeal airway volume in the three groups (graph 1).



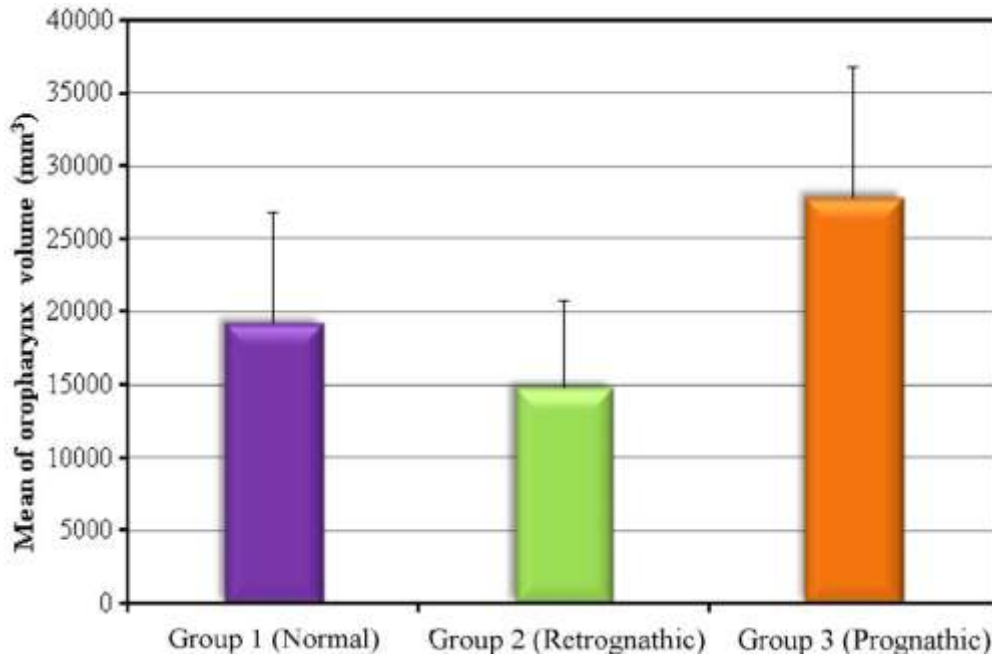
Graph 1:- Comparison between the three studied groups according to nasopharyngeal airway volume.

There was a statistically significant difference in mean oropharyngeal airway volume in the three groups; where group 3 (prognathic) showed the highest oropharyngeal airway volume and group 2 (retrognathic) showed the lowest oropharyngeal airway volume (table 1 & graph 2).

Table 1:- Descriptive statistics of oropharyngeal airway volume in each studied group.

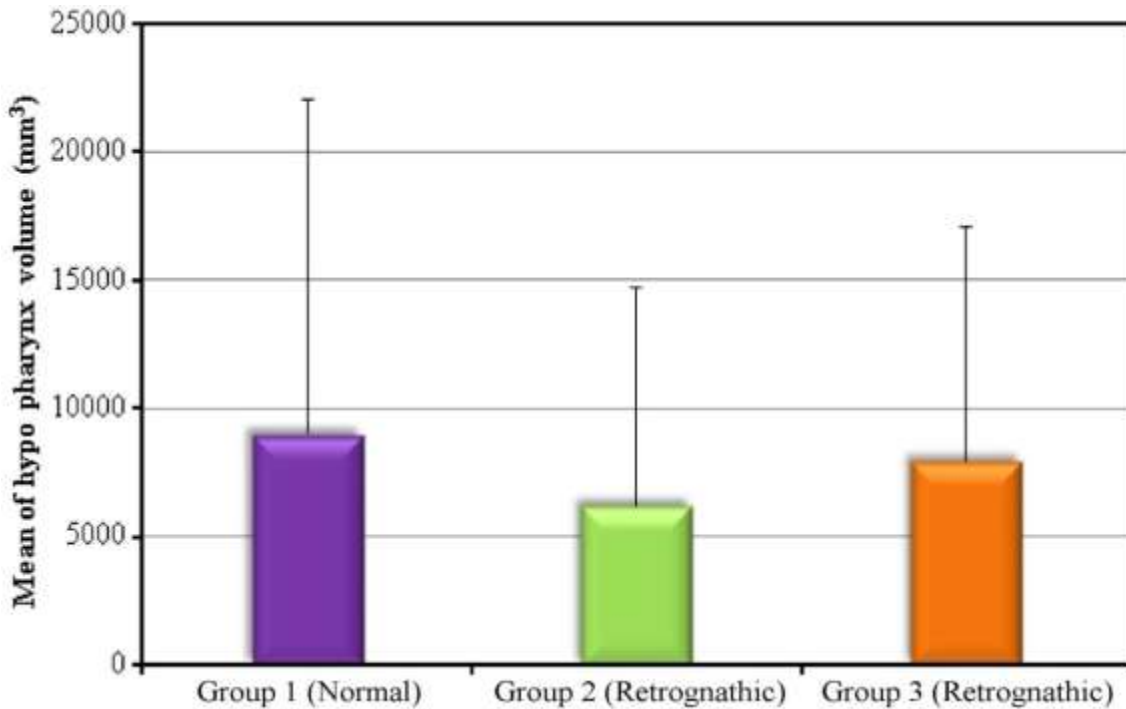
| Groups | Oropharyngeal airway volume (mm ³) | | | | | |
|--------|--|------|------|-----|--------|--------|
| | Min. | Max. | Mean | ±SD | Median | 95% CI |
| | | | | | | |

| | | | | | | LL | UL |
|-------------------------------|---------|---------|---------|--------|---------|---------|---------|
| Group 1 (Normal) | 9556.3 | 27646.3 | 19201.2 | 7630.1 | 20546.5 | 12144.5 | 26257.9 |
| Group 2 (Retrognathic) | 5927.0 | 23030.0 | 14767.0 | 5974.1 | 14531.9 | 9241.9 | 20292.2 |
| Group 3 (Prognathic) | 15964.0 | 42655.1 | 27853.9 | 8960.2 | 25977.7 | 19567.1 | 36140.8 |



Graph 2:- Comparison between the three studied groups according to oropharyngeal airway volume.

There was a statistically non-significant difference in the mean of hypopharyngeal airway volume in the three groups (graph 3).

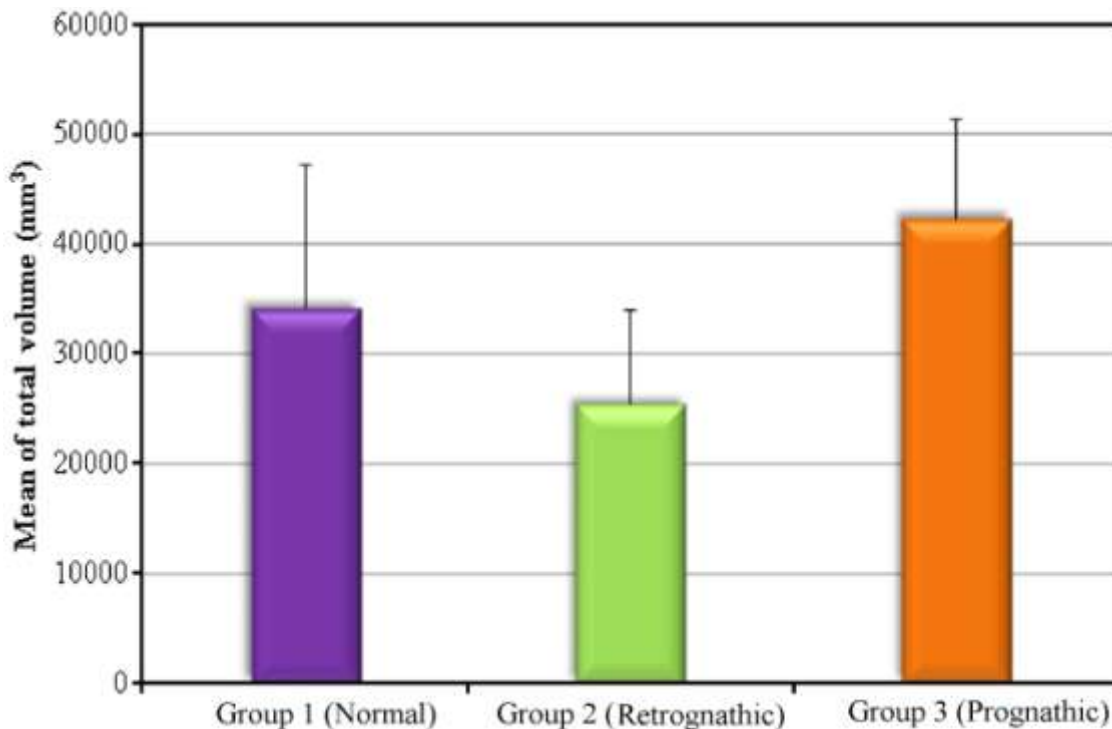


Graph 3:- Comparison between the three studied groups according to hypopharyngeal airway volume.

There was a statistically significant difference in mean total pharyngeal airway volume in the three groups; where group 3 (prognathic) showed a higher total pharyngeal airway volume and group 2 (retrognathic) showed the lowest total pharyngeal airway volume (table 2 & graph 4).

Table 2:- Descriptive statistics of total pharyngeal airway volume in each studied group.

| Groups | Total volume (mm ³) | | | | | | |
|------------------------|---------------------------------|---------|---------|---------|---------|---------|---------|
| | Min. | Max. | Mean | ±SD | Median | 95% CI | |
| | | | | | | LL | UL |
| Group 1 (Normal) | 15705.4 | 51756.7 | 34172.8 | 13033.9 | 37493.8 | 22118.4 | 46227.2 |
| Group 2 (Retrognathic) | 15130.0 | 37169.6 | 25440.7 | 8438.8 | 24589.5 | 17636.1 | 33245.2 |
| Group 3 (Prognathic) | 28602.4 | 57697.4 | 42344.1 | 9101.3 | 42403.1 | 33926.9 | 50761.4 |



Graph 4:- Comparison between the three studied groups according to total pharyngeal airway volume.

There was a statistically significant difference in mean of SNB angle in the three groups. As the SNB angle increases, total pharyngeal airway volume (mm³) increases.

Discussion:-

The relationship between craniofacial morphology and respiratory function has been the focus of investigation since the late 19th century. It has been studied that pharyngeal airway is influenced by the antero-posterior position of maxilla and mandible but some authors as Kula et al (2015) mentioned that different skeletal and dental malocclusions have no effect on upper airway volumes.

CBCT was used for this study because it has the advantages of easy accessibility, short acquisition time and better 3 dimensional assessment and visualization of the airway than radiographs that show only 2 dimensions. It also allow 3 dimensional volumetric images to be compared by using measurements in a 1-1 ratio with less distortion and magnification. (Hong, J.S. et al., 2011; Castro-Silva, L. et al., 2015).

For the nasopharyngeal airway volume, it was found that the mean volume was larger in prognathic group (3), followed by normal mandibular position group (1), followed by the retrognathic group (2). Differences between

groups were not statistically significant. Similar to the current study, Oh et al (2011) found that Class II patients showed a smaller nasopharyngeal airway volume than Class I and Class III patients. However, they did not mention which jaw is causing the malocclusion. Zheng et al (2014) also found that nasopharyngeal airway volume of Class I and Class III were larger than that of patients with Class II skeletal pattern. However, this difference was found to be statistically significant. This statistical difference may be due to using different anatomical landmarks for the nasopharynx.

For the oropharyngeal airway volume, it was found statistically significant difference between the 3 groups. The mean oropharyngeal airway volume was greater in group 3 (prognathic), followed by group 1 (normal), followed by group 2 (retrognathic). El and Palomo (2011) found similar results to this study and stated that oropharyngeal airway volume with retruded mandibular position is more likely to result in a smaller oropharyngeal dimensions. However, Memon et al (2012) suggested that clear differences in the upper airway dimensions with different craniofacial patterns could not be established. A point of weakness for Memon et al (2015) results is that their study was held on 2D lateral cephalometric radiographs.

In the current study, a statistically insignificant difference between hypopharyngeal airway volume between the 3 groups was found; being group 1 larger than group 3, and group 3 larger than group 2. Kula et al (2013) found insignificant difference between the 3 groups similar to this study. However, Zheng et al (2014) found a significant difference between the 3 groups with a hypopharyngeal airway volume larger in Class III, followed by Class I, followed by Class II. The difference may be due to using different borders and landmarks for the hypopharyngeal airway. The upper and lower borders for Zheng et al (2014) study was depending on bony landmarks while in this study, the upper and lower borders depended on soft tissue landmarks.

In this study, the mean total pharyngeal airway volume was greater in group 3 (prognathic) followed by group 1 (normal), then group 2 (retrognathic). These differences were statistically significant and matched the results of Alves et al (2012) who stated that pharyngeal airway space was statistically smaller with mandibular deficiency. Moreover, Hong et al (2011) stated that the volume of upper part of pharyngeal airway space increases with increasing the SNB angle (mandibular prognathism). Similar to our study, Castro-Silva et al (2015) found that patients with retrognathic mandible have a decreased pharyngeal airway space when compared to patients with normal and prognathic mandible. They also stated that the mean volume for Class III patients with mandibular prognathism was statistically greater than that for Class I normal mandibular position and Class II patients with mandibular retrognathism, and the volume for Class I is greater than that of Class II patients.

On the other hand, Di Carlo et al (2015) found that the mean partial and total pharyngeal airway volume were not significantly different between various skeletal malocclusions. This may be due to using the ANB angle as the detector for the malocclusion with possibility of variation of anteroposterior position of both maxilla and mandible. This may also be due to scanning the patients is a supine position where collapsing of the airway is more likely to happen.

Conclusion:-

- 1- Pharyngeal airway volume differs with different sagittal positions of the mandible in adults.
- 2- Pharyngeal airway volume decreases with mandibular retrognathism and increases with mandibular prognathism.
- 3- There is a significant difference in total pharyngeal and oropharyngeal airway volume between the 3 studied groups.
- 4- There is a non-significant difference in mean nasopharyngeal and hypopharyngeal airway volume between the 3 studied groups.

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