ORIGINAL ARTICLE

Pharyngeal Airway Dimensions Assessed by Acoustic Pharyngometry in a Mixed Indian Population: A Cross-sectional Study

Sanjeev Datana[1], Shiv Shankar Agarwal[2], Prasanna Kumar[3], Mohit Sharma[4]

Abstract

Background: Acoustic pharyngometry (AP) is a noninvasive modality for the assessment of upper airway dimensions. Early detection of structural narrowing of the upper airway may enable the clinician early detection of upper airway sleep disorders like obstructive sleep apnea (OSA). At present, norms for various airway parameters assessed on AP for the Indian population are not available.

Material and methods: This cross-sectional study was conducted on AP records of 560 subjects (428 males and 132 females) in the age-group of 20–40 years. The study included subjects with body mass index (BMI) and neck circumference within normal limits, having a straight facial profile and Angle's class I with no discrepancy in transverse, sagittal, and vertical dimensions. The data were analyzed using a statistical package for social sciences (SPSS version 21.0, IBM Corporation, USA) for MS Windows.

Results: The results of the study indicated that the mean volume of the pharyngeal airway in males and females was 27.98 cm^3 and 28.5 cm^3, respectively. The mean area in males and females was 2.84 cm^2 and 2.85 cm^2, respectively. The minimum area in males and females was 1.76 cm^2 and 1.74 cm^2, respectively.

Conclusions: The mean values of various airway parameters obtained in the present study can serve as reference values in respect of the mixed Indian population and as a guideline for screening of large number of patients, especially with regard to the detection of the compromised upper airway.

Keywords: Acoustic pharyngometry, Mixed Indian population, Upper airway.

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Introduction

Pharyngeal airway is an important anatomical requisite for favorable growth and development of the craniofacial structures. The relationship between pharyngeal, oral, and craniofacial structures determines their mutual interaction during life and various stages of growth and development.[1,2] Early detection of structural narrowing of the upper airway may enable early detection and management of upper airway sleep disorders like obstructive sleep apnea (OSA). However, it is necessary to compare the individual subject's data with those of existing norms in the literature to arrive at a conclusion so as to determine or quantify the amount of deviation of parameters in the subject under consideration with regard to those of existing norms.

Various techniques like lateral cephalogram, cone beam computed tomography (CBCT), fluoroscopy, acoustic reflection technique (ART), fiberoptic pharyngoscopy, magnetic resonance imaging (MRI), etc. have been reported in the literature for the assessment of upper airway dimensions.[3,4] However, most of these studies have been done either on 2D modalities like lateral cephalograms or more recently on 3D modalities like CBCT, both of which fail to assess the upper airway in a dynamic state as these methods are static in nature. These cutting-edge techniques for airway assessment are more expensive, incur extra cost and radiation exposure to the patient, may not be accessible at all places, and, most importantly, are invasive procedures.[5] Acoustic pharyngometry (AP) is a relatively newer technique used to assess pharyngeal airway in three dimensions and also in a dynamic state. It works on the principle of acoustic reflection in which there is a reflection of sound waves that are projected down the subject's airway through a mouthpiece and are reflected back and assessed by the processing unit to display the results on the computer. The validity of this technique in measuring upper airway has been well established in the literature, and the pharyngeal airway dimensions measured by this technique have been found to be comparable to those obtained by computed tomography[6] and MRI.[7]

In modern-day practice, the demand for orthodontic treatment is primarily for improvement in the facial profile and smile esthetics of the patient. Ethnicity that influences the skeletal and dental parameters definitely plays a critical role in the planning of treatment for orthodontic and orthognathic surgical corrections in these patients. One of the goals of orthodontic treatment includes meticulous assessment of upper airway dimensions prior

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to treatment and improvement and/or maintenance of optimal upper airway area and volumes postorthodontic or ortho-surgical treatment.

The AP norms of one ethnic group may not be applicable to another ethnic group because of the marked difference of the craniofacial morphology (and thereby upper airway dimensions) in different ethnic groups. Studies involving the assessment of pharyngeal airway space with AP are limited in orthodontic literature. In addition to this, at present, there are no norms for Indian subjects regarding the pharyngeal airway dimensions as determined by pharyngometry. Hence, the present study was undertaken to obtain the measurements of the upper airway through AP analysis in healthy adult Indian subjects with no existent facial deformity. It aims to obtain preliminary data to establish normal values and range of upper airway dimensions by AP in both sexes for its larger clinical use in the mixed Indian population.

Materials and Methods

Study Design

Cross-sectional record-based study.

Sample Size Estimation

This study was undertaken in the Department of Orthodontics and Dentofacial Orthopedics of a tertiary care teaching institute. Sample size estimation was based on convenient sampling. AP records of 560 subjects (428 males and 132 females) in the age-group of 20–40 years (Table 1; Fig. 1) who underwent routine AP evaluation at the department between January 1, 2016 and October 31, 2020, were selected for the study.

Table 1: Descriptive statistics of mean volume, mean area, and minimum area

	Sex	*No. of subjects (N)*	*Mean*	*Std. deviation (SD)*
Mean volume (cm^3)	Male	428	27.98	7.52
	Female	132	28.05	7.48
Mean area (cm^2)	Male	428	2.84	0.74
	Female	132	2.85	0.78
Minimum area (cm^2)	Male	428	1.76	0.56
	Female	132	1.74	0.54

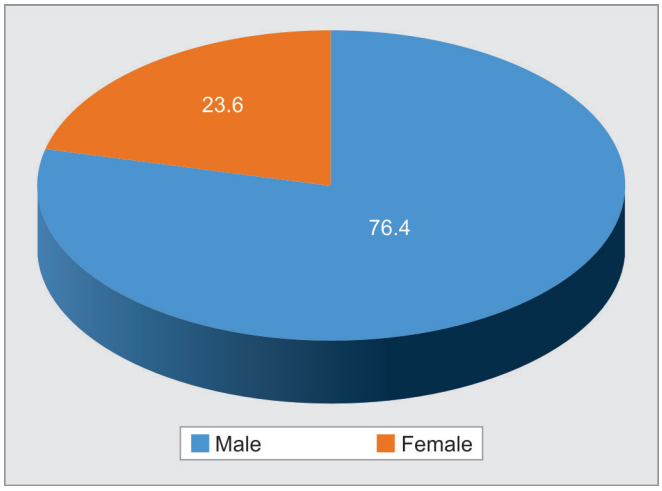

Fig. 1: The Gender distribution of the cases studied

The patients were clinically examined by a calibrated orthodontist to ascertain a pleasing straight profile with class I skeletal bases and Angle's class I molar and canine relationship bilaterally with harmonious craniofacial dimensions in transverse, sagittal, and vertical planes. Body mass index (BMI) was determined by measuring the height and weight of each individual. The neck circumference of the participants was measured in centimeters (cm) up to the nearest 1 millimeter (mm) using a measuring tape.

Inclusion and Exclusion Criteria

The study included subjects having a straight facial profile with class I skeletal bases and Angle's class I malocclusion. Subjects with BMI >25 and neck circumference ≥34.75 cm for males and ≥31.75 cm for females[8] were excluded from the study. Subjects having class II or class III malocclusions, craniofacial anomalies, syndromes, cleft lip or palate, or signs and symptoms of dysfunction of the masticatory apparatus were excluded. Subjects who gave a history of snoring, disturbed sleep, waking up in night gasping for breath, tiredness in the morning, and excessive daytime sleepiness were also excluded from the study. Subjects giving history suggesting of upper airway problems like frequent nasal congestion, prolonged cough, and recurrent tonsillitis were also not considered for the study.

All subjects were examined by AP (Eccovision, Sleep Group Solutions) to determine the upper airway dimensions. A standard procedure as recommended by the manufacturers was followed for the acquisition of AP for all patients. The patients were asked to sit on a straight-backed chair without head support with their back straight during normal breathing. The individuals were asked to look straight forward at a point ahead at eye level and to remain still and keep the tongue in a relaxed and neutral position. A mouthpiece attached to a wave tube was placed in the mouth and held parallel to the floor. The acoustic waves emitted by the wave tube are reflected back from the pharyngeal structures by ART. These waves are recorded in the monitor as a curve called as AP. The pharyngogram depicts mean airway volume, mean area, and the minimum airway dimensions. A repeat pharyngogram after the intervention, such as oral appliance therapy, depicts the percentage change in these parameters. A representative pharyngogram is shown in Figure 2. The upper airway parameters derived were entered in excel sheets, and the entire data were statistically analyzed using a statistical package for social sciences (SPSS version 21.0, IBM Corporation, USA) for MS Windows.

Results

The results of the study indicated that the mean volume of pharyngeal airway in males and females was 27.98 cm^3 and 28.05 cm^3, respectively (Table 1; Fig. 3). The mean area in males and females was 2.84 cm^2 and 2.85 cm^2, respectively. The minimum mean area in males and females was 1.76 cm^2 and 1.74 cm^2, respectively (Table 1; Fig. 4).

Discussion

The craniofacial skeleton undergoes constant change throughout the life of the individual secondary to the functional requirements.[9] The influence of pharyngeal airway on growth and development of craniofacial structures, its physiology, and various influences that contribute toward its patency and collapsibility during sleep and

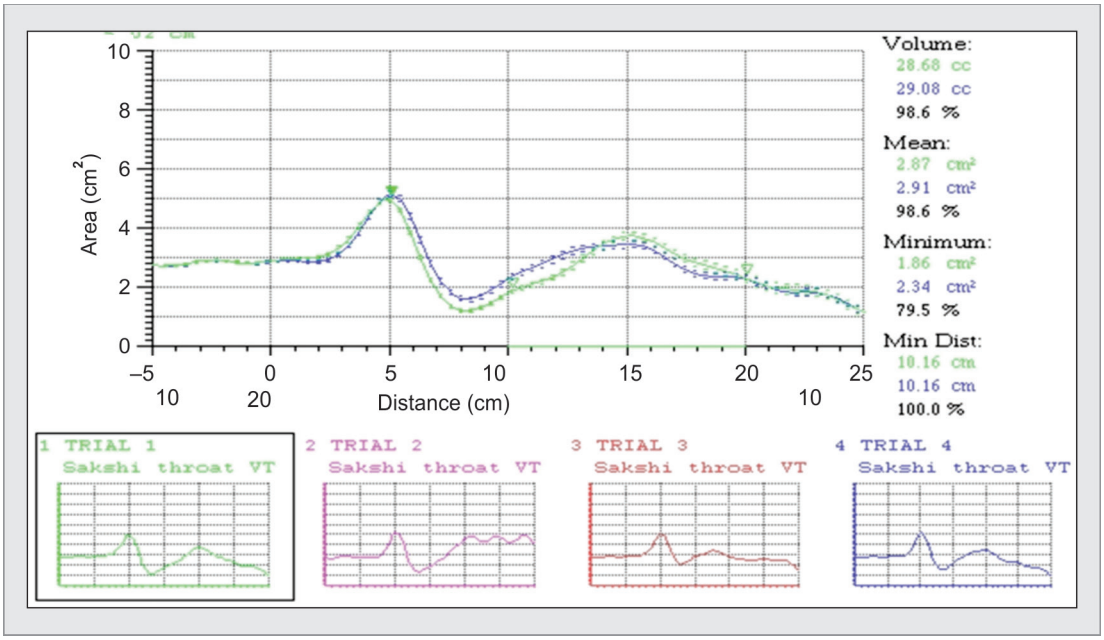

Fig. 2: Acoustic pharyngogram

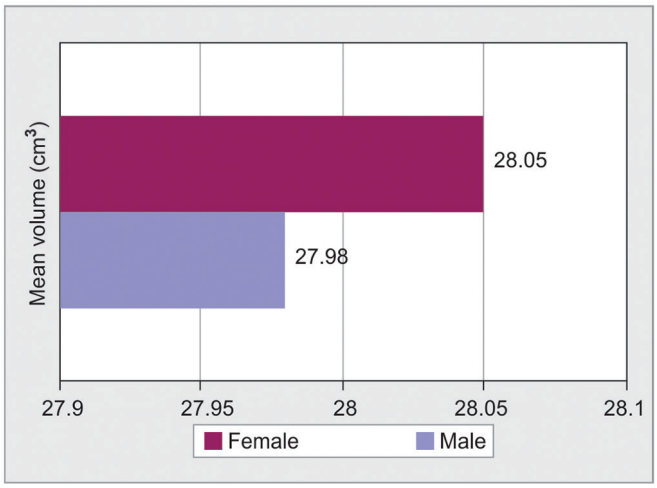

Fig. 3: Distribution of mean volume (cm^3)

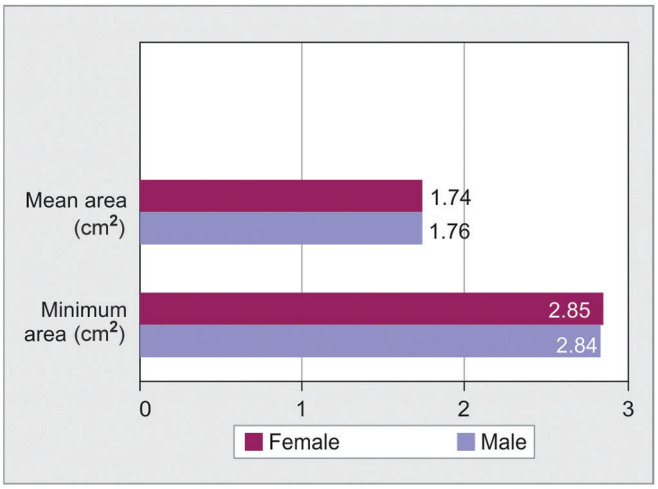

Fig. 4: Distribution of mean minimum area (cm^2) and mean area (cm^2)

subsequent breathing disorders has been the topic of extensive research in orthodontic literature.[10] Any condition or treatment factors leading to the reduced distance between maxilla or mandible and the posterior pharyngeal wall leading to posterior positioning of the soft palate and tongue may impair respiratory function and predispose the individual to the development of upper airway disorders, such as snoring, upper airway resistance syndrome, and OSA. This necessitates meticulous evaluation of upper airway dimensions during orthodontic treatment planning.[11]

The validity of AP for its clinical application depends upon both reproducibility and accuracy of upper airway measurements recorded by this modality. The acoustic measurements were authenticated by Jackson and Kervans.[12] Fredberg et al. utilizing glass models and chest radiographs authenticated acoustic measurements of the trachea in human beings.[13]

India is a vast country with diverse population groups of different ethnicity and cultural origins. Maharashtra being the second most populous and geographically third largest state of the country is characterized by the inhabitation of a mixed Indian population, including natives and migrants from throughout the country. A study of this population would yield values representative of a mixed Indian population, which can be utilized in clinical practice. With respect to the upper airway study by pharyngometry, no such norms exist for the mixed Indian population till date. Hence, this study was undertaken.

The mean upper airway area obtained in the present study was $2.84 + 0.74\ cm^2$ in males and $2.85 + 0.78\ cm^2$ in females. When comparing our results with those carried out by Brigadier General Kamal,[14] the measurements obtained in the present study are slightly lesser in males and almost similar for females.

Comparing our study with a study by Samman,the measurements of the area obtained in the present study are lower. In comparison to the study by Kaur,[15] the area measurements obtained in the present study are slightly lower for males and higher for females. Our study reveals an area of 2.84 + 0.74 cm^2 when compared to that of 3.035 cm^2 for males in their study and a slightly higher area for females which according to our study is 2.85 + 0.78 cm^2 when compared to that of 2.75 cm^2 in their study. Overall, the results of area measurement in the present study are in consonance with that of area measurements obtained by other methods in the literature.

The mean upper airway volume obtained in the present study was 27.98 + 7.52 cm^3 for males. On comparing this with a study conducted by Dan Grauer,[16] the airway volume obtained in the present study is greater when compared to the mean volume of 20.3 + 7.3 cm^3 in their study. However, it needs to be considered that their study was based on CBCT. In addition to this, when the upper airway volume was compared to the study by Mevlut Celikoglu,[17] the measurements obtained in the present study are slightly greater in both males and females.

Although some differences were observed in the airway parameters of males and females in this study, the overall curvature followed by the pharyngogram was similar in all subjects. Hence, it can be inferred that despite the fact that males and females have different pharyngeal cross-sectional areas, it does not affect the geometric configuration of the curve. Both males and females showed the same curve topography in our study.[18,19]

Conclusion

The mean values of various airway parameters obtained in the present study can serve as reference values in respect of mixed Indian population and as a guideline for screening of a large number of patients, especially with regard to the detection of the compromised upper airway. However, a multicenter study with a larger sample size is recommended to validate the findings of this study.

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