



Integrating Acoustic Pharyngometry And Rhinometry In Orthodontic Practice And Training

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ABSTRACT

Orthodontics and dentofacial orthopedics, the first specialty of dentistry aims for correction of malocclusion, by movement of teeth, orthopedic changes in jaw bones with growth modulation or by ortho-surgical planning for the varied skeletal malocclusion. Rapid Palatal Expansion (RPE) for treatment of maxillary constriction, growth modulation with forward posturing of lower jaw with myo-functional appliances and surgical repositioning of jaw bones with orthognathic surgery results in alteration of the nasal and oral volume. These changes affect the nasal and oral breathing patterns of the patient and may result in correction of Sleep Breathing Disorders (SBD) like Obstructive Sleep Apnoea (OSA). The conventional methods used to study these changes include 2D cephalometry, rhinomanometry etc. However, with the introduction of 3D evaluation technology of the craniofacial structures, it has helped orthodontist to evaluate these changes in volume. The contemporary methods include CT, CBCT and MRI. One less commonly explored modality in the field of Orthodontics is Acoustic Rhinometry (AR) and Acoustic Pharyngometry (AP), which is a non-invasive, non-ionizing modality to study upper airway in dynamic state. The AP device uses acoustic reflection technology to accurately map out the size, structure and collapsibility of the oral and nasal airway. The efficacy of the AP is found to be comparable with that of 2D Cephalometry and 3D modalities like CT, CBCT & MRI. This aim of this paper is to highlights the principal, use and importance of AP in the field of orthodontics and to advocate the use of this modality in orthodontic practice and training.

Keywords: upper airway, CBCT, clinical assessment, orthodontics.

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Introduction

World Health Organization has defined “health” as a state of complete physical, mental, and social well - being. The modern-day dental practice has emerged with an aim to improve the overall quality of life (QOL) for the patients ^[1]. Orthodontics and dentofacial orthopedics, the first specialty of dentistry, deals with correction of malocclusion, by movement of teeth, orthopedic changes in jaw bones with growth modulation or by ortho-surgical planning for the varied skeletal malocclusion. Hence, orthodontics as a specialty enhances the dentofacial esthetics and accordingly the QOL.

Assessment of upper airway and its role in growth and development of the craniofacial structures have been an area of interest to Orthodontists. Several Orthodontic procedures results in alteration of airway, the area and volume of the nasal & oral cavity. Obstruction of the upper airway may cause alteration in the breathing pattern of an individual and may impact the normal development of craniofacial structures. The clinical presentation may include constricted maxillary (transverse maxillary deficiency) with or without downward and backward rotation of mandible. These clinical conditions require early attention and hence can prevent permanent alteration of the craniofacial structures ^[2].

The interaction between the upper airway and the dentofacial structures has been a subject of interest for the orthodontists. It is believed that evaluation of soft tissues i.e., facial contours, tongue, tonsil, and adenoids is important in orthodontic diagnosis and treatment planning ^[2]. The various methods pronounced to assess the upper airway include: nasal endoscopy, rhinomanometry, acoustic pharyngometry & rhinomanometry ^[3,4], cephalometry, computed tomography (CT), magnetic resonance imaging (MRI) and cone-beam computed tomography (CBCT).

In orthodontics, upper airway assessment starts

with clinical examination at the initiation of treatment, continue with interpretation by lateral cephalograms and/or CBCT. Lateral cephalometry is a two-dimensional (2D) representation of three-dimensional facial structures (3D), hence, the information obtained is not complete. The CBCT is a newer modality which provides 3D information of the dentofacial structures with construction of projections on different planes, and thereby provide more accurate and volumetric measurement of the upper airway. However, it is not a routine examination and involves a larger radiation dose. Acoustic Pharyngometry (AP) is a non-invasive, non-ionizing, chairside diagnostic modality which provides three-dimensional objective measurement of the oropharyngeal airway using analysis of a reflected acoustic signal to display cross-sectional area (CSA).

This aim of this paper is to highlights the importance of airway in orthodontics, to emphasise on principal, use and importance of AP in the field of orthodontics and to advocate the use of this modality in orthodontic practice and training.

Anatomy of the upper airway

Breathing is an essential function for the survival of human beings. The atmospheric air to reach the lungs has to follows a long narrow passage, starting with the nostrils, the nasal cavity and incidentally the mouth. The upper airway is constituted by the nasal cavity and the pharynx.

The entry point for airway is the nostrils followed by the nasal cavities, and extend to the back to the nasopharynx. Uninterrupted air flow is expected through this passage however, any resistance in the passage can result in reduction of flow. Pathologies (developmental or acquired) such as nasal polyp, deviated nasal septum, a narrow nasal cavity, or turbinate hypertrophy can result in increased resistance to nasal airflow and patient may develop habit of mouth breathing and or even develop Sleep Disordered breathing (SDB) ^[5].

The oral cavity, is a very important structure not only for mastication, phonation but also for breathing. What constitutes the roof of the oral cavity is the floor of nasal cavity. The tongue occupies the curvatures within the dental arches, filling the space when the mouth is closed. Transverse development of maxilla provides adequate space for this muscular organ, however, with maxillary constriction the position of the tongue may shift to much lower and posterior position. Tongue being a muscular organ maintains its tone during various functions however, the muscle tone decreases during sleep. Along with the reduced muscle tone of the pharyngeal walls and the soft palate during sleep, the fall of tongue is the main cause of the collapse of the airway resulting in obstructive sleep apnea (OSA) syndrome. The enlarged palatine tonsils, especially in young patients can be another point of increased resistance to air flow.

The pharynx is a muscular tube-like structure measuring approx. 12-14 cm in length. The nasopharynx, the upper part pharynx is located posterior to the nasal cavity and superior to the soft palate. The lymphoid tissue collection, adenoids (pharyngeal tonsil) are located in the roof submucosa, when enlarged may result in obstruction to the passage of air through the nasopharynx. The oropharynx extends from the second to the fourth vertebra, superiorly at the soft palate, and inferiorly at the lingual side of the epiglottis. The tongue can be the main obstructive element in this anatomical area. The laryngopharynx continues with oropharynx at the pharyngoepiglottic fold and hyoid bone. The abnormal position of hyoid bone may influence the airway dimensions and contribute to increased resistance to air flow.

Clinical examination for upper airway

Clinical examination for airway assessment includes: extraoral examination i.e., facial morphology, sagittal & vertical skeletal relation, assessment of shape and functionality of nose and nostrils [6], the intraoral examination includes

assessment of size, posture & function of the tongue, breathing pattern, evaluation of tonsils [7], uvula and the soft palate [8]. Individuals with midface deficiency, retruded mandible (skeletal Class II) often report with reduced upper airway dimensions and correction of the skeletal malocclusion improves the airway dimensions [6, 9].

Upper airway assessment

Assessment of upper airway is important to localize the etiological anatomical area and to quantify the obstruction in an individual with features of OSA. There are numerous methods enumerated in literature to study the area and the volume of nasal cavity, oral cavity and the upper air way. The commonly used methods include:

i) lateral cephalograms

Lateral cephalometry (Lat Ceph) is a routine radiograph employed for assessment of sagittal and vertical relation of jaw bones and is being considered as 'Gold standard'. Cephalometric analysis is being used to assess the upper air way dimensions and to study various craniofacial morphological factors related to OSA [10-13]. The plethora of information provided by the Lat Ceph (skeletal, dental, soft tissue and airway) with easy accessibility, low cost and relatively low exposure to radiation makes this method frequently used by orthodontist. However, there are some inherent problems associated with Lat Ceph i.e., it provides a 2D view of the 3D structures and airway being a collapsible tube is not clearly seen on the radiograph. Further, there is overlapping of anatomical structures and there can be marking errors on cephalometric tracings.

ii) Cone beam computed tomography

Cone beam computed tomography (CBCT) is a 3D diagnostic modality used in maxillofacial examination, with radiation dose much lower than conventional computed tomography (CT) [14-16]. CBCT has been found to be reliable and

accurate in assessment of upper airway [2,12,14,15,17] and complete information and exact location can be obtained i.e., mean area and volume of given cross section of segment, airway shape as well as total volume. The accuracy of CBCT in measuring upper airway manually and semi-automatic segmentation is well documented [17,18]. The advantage of CBCT over Lat Ceph in assessment of upper airway is the 3D reconstruction of the anatomical structures (volumetric assessment), hence guiding orthodontist for more accurate diagnosis and better treatment planning [19]. However, drawbacks of CBCT include acquisition errors, distortion due to movement of patient, variations in spatial resolution [12] and radiation exposure.

iii) Magnetic Resonance Imaging (MRI)

MRI although is a non-radiation method to steady the airway, but the cumbersome procedure and the cost associated has resulted in limited use of this modality in the field of Orthodontics [20].

iv) Rhinomanometry

Rhinomanometry (RMM) objectively evaluate nasal obstruction. Active anterior RMM, most frequently used, evaluate nasal airflow in inspiration and expiration, thereby detect potential obstructions and/or resistance. Face mask is used to measure the airflow and the data generated by RMM is presented in graphical form in pressure/volume curves. Patient cooperation is required, may not be advisable for young patients.

v) Nasopharyngolaryngoscopy

This involves insertion a flexible fiberscope through the nasal cavities to study upper airway soft palate and larynx. Technique is useful in evaluation of deviations of the nasal septum, size of inferior turbinates, presence and size of the adenoid tissue, size of palatine tonsils and of the base of the tongue and its relationship with the oropharyngeal cavity, abduction of the vocal cords, subglottic diameter, and presence of masses or pathological deformities at any of

these levels [21].

vi) Acoustic Pharyngometry & Rhinometry

Acoustic Pharyngometry (AP) is a non-invasive, non-ionizing, reliable diagnostic technique in which upper airway can be assessed in three dimensions [22]. The basic concept behind the working is acoustic refraction technique in which sound waves are projected down the airway and reflected back. The acoustic reflection is analysed by the software and depicted in the form of a graph known as Pharyngogram. The technique was introduced by Jackson in 1977 [23]. AP provides a real time assessment of dynamic airway without any radiation exposure, identify the possible site of obstruction and quantify the mean area and volume of upper airway space [24,25]. The validity of this technique in measuring upper airway has been established [26] and AP measurements have been found to be comparable to those obtained by CT [27] and MRI [28].

Acoustic rhinometry (AR), based on sound reflection principle, studies the geometry of the nasal cavity and provides cross-sectional areas of the nasal cavity and nasal volumes.

Summary

Development of craniofacial structures depends upon head posture and respiratory function, hence timely and accurately assessment of upper airway is essential. In addition to clinical evaluation, various invasive and non-invasive methods have been developed for assessment of upper airway. Although, Lat Ceph is a commonly used radiograph in orthodontic practice, provides reasonable information (2D) on upper airway, availability of non-invasive, non-ionizing, chairside, dynamic modality like Acoustic Pharyngometry provides 3D information along with area of constriction. It is recommended that AP should be employed routinely in orthodontic practice and young orthodontists should be trained in AP with an aim to diagnose and intervene at early stage and to restore the health of an individual & improve

quality of life.

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