Innovations

Role of Oral and Maxillofacial Imaging in Upper Airway Assessment

Dr. M. Deivanayagi , M.D.S.,
Research Scholar,
Dr. M. G. R Educational and Research Institute
Periyar E. V. R High Road,
Maduravoyal, Chennai-600095
Dr. R. Saravanan, M.D.S.,
Professor, Department of Orthodontics
Thai Moogambigai Dental College and Hospital Chennai – 600 107
Dr. N. Raj Vikram, M.D.S.,
Professor , Department of Orthodontics
Thai Moogambigai Dental College and Hospital, Chennai – 600 107
Dr. K.R. Shakila , M.D.S.,
Professor, Department of Oral Medicine & Radiology
Karpaga Vinayaga Institute of Dental Sciences, Chennai – 603308
Corresponding Author: Dr. M. Deivanayagi

Abstract: *Evaluation of upper airway space is a routine procedure in orthodontic diagnosis and treatment planning. The two-dimensional representation of three-dimensional structures as afforded by the radiographic image in cephalometry provides limited diagnostic information. Cone Beam Computed Tomography was developed with the purpose of providing a superior imaging modality in dento-maxillofacial diagnosis.* ***Objective****: To review the limits, functions and anomalies of different areas that make up the upper airway, to provide information about specific methods most widely used by specialists for their evaluation, and to describe and evaluate the information level and diagnostic accuracy of methods such as lateral cephalometric analysis and Cone Beam CT (CBCT).* ***Conclusions:*** *It is essential to know upper airway assessment methods, which include a clinical examination, a radiographic evaluation and CBCT. These will indicate possible functional changes that could interfere with treatment.*

Keywords: *Upper airway, CBCT, Clinical assessment, Orthodontics.*

Introduction

Upper airway growth function and assessment has been of interest to dental researchers for many years. Orthodontists have always had an interest in upper airway so they can measure the airway volume for patients with obstructive sleep apnea, in relation to malocclusion.

Upper airway obstruction tends to alter the breathing, which can have a significant impact on the normal development of craniofacial structures causing deficiencies in transverse maxillary growth as well as cause the rotational growth of the back of the mandible. These dentofacial abnormalities requires early detection and treatment.[1]

Assessing Upper Airway Space

Different forms of image based exams such as nasal endoscopy, rhinomanometry, cephalometry, computed tomography, Magnetic Resonance Imaging and Cone Beam CT have been used to evaluate upper airway space, skeletal structure and adjacent soft tissues. Each method has inherent advantages and disadvantages.

Cephalometry is relatively inexpensive method, upper airway alterations are occasionally treatment, after cephalometric evaluation. The use of lateral cephalometric radiographs is limited and provides only two dimensional images of the airway.The advent of three dimensional cone beam computed tomography alleviate this problem and offering improved conditions for visualization and image manipulation on a 1:1 scale and with a considering lower radiation dose , shorted scan acquisition time when compared with CT.[1,2] Besides the anatomy of the skeletal and soft tissue, airway space depends on some dynamic variables such as lung volume, intraluminal and extraluminal pressure, muscle tone and head position. Since the soft palate and the tongue are structures composed of soft tissue with no rigid support, they are greatly affected by gravitational forces. Therefore, in CT scans and other examinations performed in the supine position, these structures move further toward the posterior pharyngeal wall, which results in changes in the dimensional measurements of the upper airway space, as demonstrated by Lowe et al, Huang et al, Abramson et al and Ono et al. Thus, scan results obtained with the patient sitting cannot be extrapolated or even directly compared to those obtained with the individual in the supine position.

The latter position is recommended for individuals with OSAS. Lohse et al suggest that in assessing OSAS patients a modification be made to the CBCT acquisition technique, namely, removing the chin positioner so that the patient can hold their head in a natural position.

Three dimensional images and volumetric reconstructions can be obtained from CBCT after a complex process, which involves the use of specially designed programs.It helps to find the correct location of the boundaries of the pharynx, nasal cavity through a process than can be manual, automatic or semi-automatic. They are found to have reliable, reproducible and accurate results of linear measurements, but they loose accuracy when calculating the volume of airway. This could be due to automatic segmentation of nasal and oral cavity, nasopharynx and oropharynx.

The nasopharynx, on the sagittal plane, was delimited from the last slice before the nasal septum joins the post wall of pharynx. On the sagittal the lower boundary was determined by the palatal plane. The upper boundary of the oropharynx is the nasopharynx and the lower one is through the lowest anterior point of the second cervical vertebra.3D CBCT is a repeatable, well acknowledged imaging techniques to visualize and segment hollow structures in 3D such as airway volumes and surface areas, size of soft palate and tongue.The axial plane, which can't be seen on lateral cephalogram, is considered to be the most relevant plane from a physiological perspective because it's perpendicular to the airflow.

CBCT system have been specifically developed for the maxillofacial area. Because CBCT is three-dimensional, it allows clinicians to assess the airway space and surrounding structures, and determine three-dimensional naso-, oro- and hypopharyngeal measurements,such as the most constricted area, volume and the smallest anteroposterior and lateral pharyngeal dimensions in OSAS patients. One can also evaluate changes that might potentially be induced by the treatment modality itself, and identify which patients would benefit from such treatment

Acquiring Cbct Scans for Airway Assessment:

CT examination for assessing the airways have a specific image acquisition protocols patients must be sitting,in maximum intercuspation,with the midsaggital plan perpendicular to the horizontal plane and Frankfort plane parallel to the horizontal plane. An extended field of view of 17*23cm should be used. 0.25mm voxel size; 40 seconds. Upon completetion of scanning, raw data is reconstructed to enable visualization of 3D reconstruction and multiple planar cross sections. These two dimensional images of the

pharynx can be examined from any direction.The most commonly used are sagittal, coronal and axial.[5] Images can be better observed using specific tools.Images can be rotated and magnified, measured by linear measurement tools.Various 3D assessment softwares such as In vivo Dental, 3Dmd-vultus, Dolphin Imaging enables a wider ranges of resources useful in airway space evaluation.

Dolphin program version 11.0 features two threshold filters: For hard tissue and soft tissue space together with skeletal tissue, separately. It enables the evaluation of shape, contour of the upper airway space, volume in three dimensions. To assess image in the program, import the files in DICOM format for CBCT images. Once imported, the three dimensional image of the patients head must be oriented in the virtual space in like manner as in the cephalostat, is so that Frankfort horizontal plane is parallel to the axial plane, midsaggital plane coincides with the midline of the individual, the coronal plane is oriented in such a way that it crosses beyond the inferior borders of the right and left orbits. In asymmetry cases, orientation should be as close as possible to these reference planes.[6]

Clinical Implications and Limitations of CBCT In Assessing The Upper Airway Space

The cephalometric analysis of Mc Namara (1981) indicates the nasopharynx as a linear measurement of a midpoint on the post wall of the soft palate up to the post wall of the pharynx, at the point where the most evident constriction of the airway is detected.

O.gwa et al. investigated airway morphology in obstructive sleep apnea affected patients. The apnea affected patients showed significant reduction in airway volume, area and distance.[7]

Digital Imaging and Communications in Medicine (DICOM) viewer software is necessary to allow viewing, measuring, segmenting and complete analysis of CBCT scan. The segmentation of the airway can be done either manually or automatically. There are more than 15 thirty parts DICOM viewer mainly for orthodontics, implantology. The upper airway is composed of the nasopharynx, oropharynx and hypo pharynx.An obstructive upper airway is present when obstructive process of a morphological, physiological (on pathological process shows hypertrophy of adenoids, tonsils, congenital nasal deformities, nasal traumas, polyps, tumours, chronic rhinitis and tumors causing functional imbalance).[4,8]

Upper Airway Assessment Using CBCT

El and Paloma in 2010 proposed the protocol where they performed segmentation manually and 30 cm windows (FOV) were used, through a 13 cm window is acceptable to display the oropharynx or the nasopharynx and nasal cavity. The position of patient and head position are important when CBCT is taken. The position of hyoid bone and tongue and dimension of the airway would be highly reproducible using natural head position. It has been found that individuals would be approximately 40% more affected by the width of the airway in an upright position.

Alsfyani stated that images must be obtained with the patient in a sitting position so as not to affect among width. Several limitations must still be overcome, the impact of the respiratory phase and the definition of the anatomic boundaries of the upper airway as well as the lack of consistency in the configuration of the equipment and in low images and volumetric reconstruction are obtained.

The upper airway space can be described in terms of height, width and depth. It is known that the limiting factor determining respiratory capacity is a reduced cross sectional air passage area anywhere in the pharyngeal path.

Upper Airway Space Assessment and OSAS

Obstructive Sleep Apnea Syndrome (OSAS) is a disease characterized by the collapse of the pharyngeal airway space resulting in repeated episodes of air passage obstruction, decreased oxygen saturation and sleep disruption. Collapse may occur at different spots in the upper airway space of OSAS

patients. The retroglossal and retro palatal regions are most frequently involved. The mandible and hyoid bone are the major skeletal determinants of the airway space.Any abnormality in these structures can affect the airway space and cause SAOS. [9]

Treatment of OSAS is primarily geared towards airway space maintenance, which is achieved with the use of a ventilation therapy device named CPAP—continuous positive airway pressure—which provides a constant air flow while keeping the airways open. Secondarily, treatment seeks to make the airway space less likely to collapse. Increased pharyngeal airway space can be obtained in a reversible manner, with the use of removable appliances, or permanently, with surgery. When secondary treatments are needed, the most constricted oropharyngeal area must be identified in order to determine an appropriate treatment solution. To be able to assess upper airway space morphology, determine the degree and location of constriction and evaluate the effectiveness of treatment, examinations such as nasopharyngoscopy with Muller maneuver, fluoroscopy, cephalometry, rhinomanometry, MRI and CT have been employed.

Cephalometric studies have shown that individuals with OSAS have smaller, retruded mandibles, narrowing of the posterior airway space, larger tongues, more inferiorly positioned hyoid bone and retro positioned maxilla when compared with non-OSAS individuals. Although this information is valuable, it does not enable clinicians to have access to the complex morphology of the upper airway space. Haskell et al asserted that it was possible to predict the amount of increase in total volume and in the cross-sectional area of the oropharynx obtained through appliance-induced mandibular advancement, since the most constricted area could move to any higher or lower point in the pharynx. They argued therefore that CT evaluation would be necessary prior to installing the appliance to determine whether the patient would benefit from its use. They further stressed that, in treating OSAS, it is more important to achieve improvement in the most constricted area than to increase the volume of the pharynx as a whole.[9,10]

Conclusion

An attempt is made to provide and update the knowledge of various oral and maxillofacial imaging in upper airway assessment to assist the clinician and researchers in order to help in early detection and treatment planning for patients with severe malocclusion. Lateral Cephalograms have intrinsic limitations that result in distorted images. The impact of three dimensional imaging modality (CBCT)has gained wide acceptance during the last 8 years. It is necessary to understand the limitations and pitfalls associated with available imaging methods in order to fully appreciate and correctly apply in hard and soft tissue analysis.

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