European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 7, Issue 07, 2020

Lateral Cephalogram and CBCT as a diagnostic aid for analysis of airway- Review Article

S. Banerjee [1], S. Shrivastav [2], K. Ranjit[3], P. Dhannawat [4]

[1]Dr. Somya Banerjee, Post Graduate student, Department of Orthodontics and Dentofacial Orthopedics, Sharad Pawar Dental College and Hospital, Datta Meghe Institute of Medical Sciences, Sawangi, Wardha, Maharashtra.
[2]Dr. Sunita Shrivastav, Prof. and dean examination, Department of Orthodontics and Dentofacial Orthopedics, Sharad Pawar Dental College and Hospital, Datta Meghe Institute of Medical Sciences, Sawangi, Wardha, Maharashtra.
[3]Dr. Ranjit Kamble, Prof. and H.O.D. Department of Orthodontics and Dentofacial Orthopedics, Sharad Pawar Dental College and Hospital, Datta Meghe Institute of Medical Sciences, Sawangi, Wardha, Maharashtra.
[4]Dr. Purva V. Dhannawat, Post graduate student, Depatment of Orthodontic and Dentofacial Orthopedics , Sharad Pawar Dental College, Datta Meghe Institute of Medical Sciences, Sawangi (Meghe), Wardha, Maharashtra, India;

Email ID: [1]somyabanerjee9@gmail.com, [2]sunitashrivastv92@gmail.com, [3]ranjitkamble2506@gmail.com, [4]purvavdhannawat@rediffmail.com

Abstract:
Introduction- As we know that form follows function, the altered nasorespiratory function can lead to altered craniofacial growth. This predisposes to mouth breathing, OSA, adenoid hypertrophy which are a matter of grave importance today. Many orthodontic procedures may lead to reduced lower airway space if underlying conditions are not paid enough attention to. This forces the orthodontist to be more precise in their diagnosis and treatment planning especially planning formulated in accordance with obstructive sleep apnoea. The early diagnosis and early intervention of these conditions can prevent more severe associated problems. There are multiple evaluations of airway status undertaken by anesthetist and ENT surgeon some of which may benefit orthodontist for timely intervention. These methods include roentgenograms, CT, CT bronchography, virtual bronchoscopy, MRI, 3D printing, Ultrasonography, Nasal endoscopy, rhinomanometry. CBCT and lateral cephalogram are the most commonly used diagnostic tool for airway analysis. The reliability of lateral cephalogram in the analysis of airway has been questioned several times in the past few years which puts up a need for evaluation of the technique and its reliability.
Objective- The aim of this article is to review all those literatures that relate to upper airway analysis using Lateral cephalogram to those of CBCT scans and to evaluate the reliability of lateral cephalogram.

Conclusion- Lateral cephalogram can be used as an initial diagnostic aid for the analysis of airways. Although the three-dimensional airway is analysed using two-dimensional technique it is nonetheless an appropriate diagnostic tool for airway analysis.

Keywords- Nasopharynx, Velopharynx, adenoidal hypertrophy, CBCT, lateral cephalogram, Obstructive Sleep Apnoea

1. INTRODUCTION

During the past few decades, airway analysis is receiving more and more attention in orthodontics because of its relation with the growth of craniofacial skeleton and also with obstructive sleep apnoea (OSA) [1][2][3]. Along with Obstructive Sleep Apnoea other breathing abnormalities varying from snoring (chronic or habitual) to upper airway resistance syndrome are also associated with difficult airway. Difficult airway can be the result of various factors including adenoidal hypertrophy and tonsillar hypertrophy, chronic and allergic rhinitis, allergens or irritants, infection involving the airway tract, congenitally deformed nose, nasal traumas, nasal polyps, and tumors[4]. Treatment procedures such as mandibular setback also causes reduction in lower airway space due to posterior positioning of tongue and predisposes to obstructive sleep apnoea.[5]

The nasal airway patency depends on the dimensions and morphology of Nasomaxillary complex, the nasopharynx and the oropharynx. If the resistance in this passage increases, nose breathing is replaced by mouth breathing. This change affects the growth of the craniofacial skeleton including maxilla and mandible since form follows function. As we know that origin, growth, position and maintenance of skeletal tissues of face are always secondary response to function, so, any aberrancy in proper nasorespiratory function such as mouth breathing or any other deviation from normal can lead to altered craniofacial growth. This altered craniofacial growth predisposes to deficiencies in transverse maxillary growth, rotational growth of the back of the mandible and anomalies like altered speech, malocclusions, Obstructive Sleep Apnoea, adenoid hypertrophy which are a matter of grave importance today.

The early diagnosis and early intervention of these conditions can prevent more severe associated problems. This becomes all the more necessary in growing patients with skeletal discrepancies to allow normal growth and development of craniofacial skeleton [6][7]. Analysis of airways in these modern times can be done by various methods including roentgenograms, CT, CT bronchography, virtual bronchoscopy, MRI, 3D printing, Ultrasonography, Nasal endoscopy, rhinomanometry. In orthodontics, analysis of airway alteration should always be done before the beginning of treatment procedure.

The most commonly utilised technique in the evaluation of airway are 2-D cephalograms, producing 2-D reconstruction of 3-D structures. With the introduction of CBCT, the orthodontists can easily carry out procedures involving 3-D analysis of airway. CBCT provides 3D evaluation, measurement of volume of various structures including the construction of projections on different planes, and thus providing a significant amount of information on diagnosis. However, it is not a diagnostic tool used for routine examination as it involves a larger radiation dose.

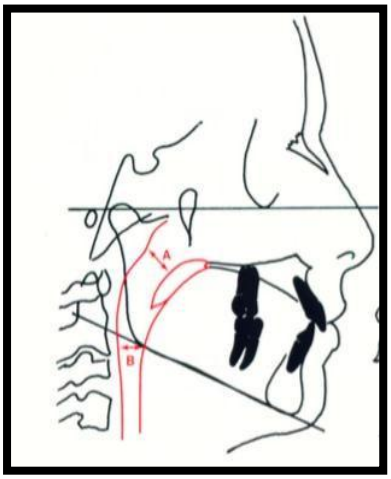
The aim of this article is to review all those literatures that relate to upper airway analysis from Lateral cephalogram to those of CBCT scans.

AIRWAY ASSESSMENT USING LATERAL CEPHALOGRAM

Because of its accessibility, low cost, low radiation exposure and simplicity, lateral cephalogram is the most commonly used method of airway analysis. With the help of Cephalometric tracing one can identify different characteristics that may indicate a narrow or constricted upper airway. The linear measurements obtained from lateral cephalograms and the dimensions of nasopharyngeal regions can be reliable, but have not been proven to be valid to measure the airway in the posterior region of the tongue [8]. There are studies in the literature quantifying the changes of structures related to airway before and after the use of myofunctional appliances or orthognathic surgeries viewed while using the lateral cephalogram [9].

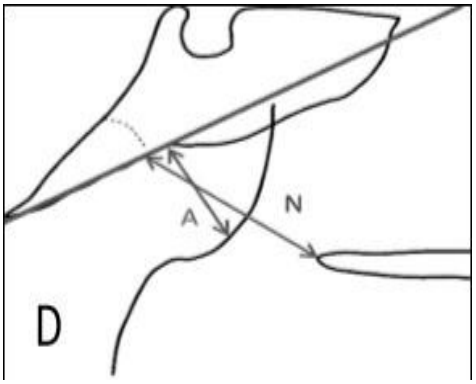
There are few limitations to the use of Lateral cephalogram, those being reproduction of (2D) image of a (3D) structure leading to distortion of image, magnification, lack of transverse dimensions in the image thus produced. Also, superimposition tracings of bilateral craniofacial structures resulted in complex airway structure assessment [10][11] However, the differentiation between OSA and non OSA patients can be easily carried out via the measurements of lateral cephalogram.

According to McNamara in 1984, an airway is said to be narrow if the distance between the nearest points of the posterior wall of the nasopharynx and of the soft palate is lower than 5 mm. But this is only an indicator of airway impairment and not a confirmatory diagnosis.



A- Upper Airway
B- Lower Airway

In 1979, According to Fujioka et al., ratio of length of the line right angle to sphenoid bone by the thickest portion of the adenoids with the distance between the posterior nasal spine and the anterior edge of the sphenobasioccipital synchondrosis (N) is the adenoid-nasopharyngeal ratio (AN ratio). The value of AN if is less than 0.8, it is considered to be normal and if more than that, it is considered to be enlarged.



Also, Feres, Murilo et al. in 2012 found that there was good reproducibility and a variability with both the parameters which was not clinically significant.
So, lateral cephalometry can be considered as a dependable screening tool for airway analysis (Major, 2006).

AIRWAY ANALYSIS USING CBCT

Since its creation in 1990, the CBCT has been well adopted for diagnosis in the maxillofacial area, as it provides a 3D representation of the structures at a low cost and with an effective radiation dose which is much lower when compared to computed tomography (CT). Although CBCT is less effective than CT in tissue discrimination, the spatial resolution to describe the boundaries between tissues as well as empty spaces is very high. In addition, several studies have shown that it is accurate and reliable for upper airway assessment.
Volumetric reconstructions that may be obtained from CBCTs help clinicians make a correct diagnosis and indicate a better treatment plan for some pathologies of the maxillofacial area, especially those related to the airway [12]. Three-dimensional images and volumes can be obtained from two-dimensional slices with CBCT after a complex process, which involves the use of especially designed computer program [13]. For the volumetric reconstruction and visualization of the upper airway, these software programs must allow us to find the correct location of the boundaries of the pharynx and nasal cavity (segmentation) through a process that can be manual, automatic or semi-automatic.
While assessing the volume of the airway we should consider the differences in the anatomical boundaries of the nasopharynx and oropharynx. The upper boundary of the nasopharynx and the lower boundary of the oropharynx have the greatest variability, followed by the boundary between these two structures [14][15][16]. The oral cavity and the nasal cavity do not show variability in their boundaries.
We must also consider the head position and the position of the patient when the CBCT is taken, to obtain accurate and repeatable upper airway measurements and volumes. The position of the hyoid bone and tongue, and the dimension of the airway would be highly reproducible using the natural position of the head while taking lateral cephalograms.
Several obstacles must still be overcome, such as the influence of the position of the tongue, respiratory phase, morphology of mandible, and the quality of the anatomical boundaries of the upper airway, as well as the lack of consistency in the configuration of the equipment and in how images and volumetric reconstructions are obtained.
CBCT has become a much used diagnostic imaging technique for orthodontists in these modern times, and the major reason for this is the decreased radiation exposure required to obtain an satisfactory image as compared to with the conventional CT[17][18] The segmentation

and visualisation of hollow structures, that is the airway can thus be done efficiently in 3-dimensions with the use of CBCT. Thus, instead of lengths and angles, a more reliable volume and surface areas are measured.

DISCUSSION

The airway is not a rigid entity and its morphology is affected by many other factors, including supine or upright positioning of the patient at the time of exposure, the influence of the position of the tongue, muscle tone, mandible morphology, inspiration or expiration, the impact of the respiratory phase, duration of X-ray exposure, amount of mouth opening and lack of consistency in the configuration of the equipment and in how images and volumetric reconstructions are obtained[19][20][21][22]. Presence of all of these factors lead to the point that even CBCT cannot include all of the above-mentioned factors and provide appropriate results accordingly.

The static image provided by lateral cephalogram of a dynamic structure that is the airway, leads to its reduced accuracy. Poor correlation between lateral cephalogram and CBCT was found out by Yucel et al in his studies [23]. Due to difference in the position of tongue or swallowing pattern Sears et al in his study found significant difference [24].

Although in several studies including the study done by Vizzotto MB et al, CBCT and Lateral cephalograms showed no statistically significant difference. In fact, Feng X, Aboudara C, found a strong correlation between these two techniques of airway assessment.

There was difference in results obtained with the change in the site of the airway from nasopharyngeal segment to velopharyngeal segment. While evaluating nasopharyngeal segment Lenza et al. and Bronoosh et al received similar values of CBCT and lateral cephalograms [25]. But when velopharyngeal segment was assessed by Lenza et al no correlation was found. Although large amount of correlelation can be found between these techniques, only one technique cannot be used always as a diagnostic aid.

CONCLUSION

In this review article it was concluded that as an initial screening tool, lateral cephalogram can be used for analysis of airway. Although the three-dimensional airway will be analysed using two-dimensional technique it is nonetheless an appropriate diagnostic tool for airway analysis. Conventional lateral cephalogram can be thus used for routine diagnostic tool for orthodontists.

REFERENCES

[1] Baliga S. Thrust areas for pedodontic research: The way ahead!. J Indian Soc Pedod Prev Dent 2017;35:283

[2] Guijarro-Martínez R, Swennen GR. Cone-beam computerized tomography imaging and analysis of the upper airway: a systematic review of the literature.
Int J Oral Maxillofac Surg. 2011;40(11):1227-1227

[3] Katyal V, Pamula Y, Daynes CN, et al. Craniofacial and upper airway morphology in pediatric sleep-disordered breathing and changes in quality of life with rapid maxillary expansion. Am J Orthod Dentofacial Orthop. 2013;144(6):860-871

[4] OoFlores-Mir C, McGrath L, Heo G, Major PW. Efficiency of molar distalization associated with second and third molar eruption stage. Angle Orthod. 2013;83(4):735-742. doi:10.2319/081612-658.1

[5] Karia H, Shrivastav S, Karia AK. Three-dimensional evaluation of the airway spaces in patients with and without cleft lip and palate: A digital volume tomographic study. Am J Orthod Dentofacial Orthop. 2017;152(3):371-381.
[6] Peltomäki T. The effect of mode of breathing on craniofacial growth--revisited. Eur J Orthod. 2007;29(5):426-429.
[7] Aboudara C, Nielsen I, Huang JC, Maki K, Miller AJ, Hatcher D. Comparison of airway space with conventional lateral headfilms and 3-dimensional reconstruction from cone-beam computed tomography. Am J Orthod Dentofacial Orthop. 2009;135(4):468-479.
[8] Alsufyani NA, Flores-Mir C, Major PW. Three-dimensional segmentation of the upper airway using cone beam CT: a systematic review. Dentomaxillofac Radiol. 2012;41(4):276-284.
[9] Stuck BA, Götte K, Windfuhr JP, Genzwürker H, Schroten H, Tenenbaum T. Tonsillectomy in children. Dtsch Arztebl Int. 2008;105(49):852-861.
[10] Ahlqvist J, Eliasson S, Welander U. The effect of projection errors on cephalometric length measurements. Eur J Orthod. 1986;8(3):141-148.
[11] PS, Hall DJ. The inadequacy of cephalometric radiographs for airway assessment. Am J Orthod. 1980;77(2):230-233.
[12] Van Vlijmen OJ, Kuijpers MA, Bergé SJ, et al. Evidence supporting the use of cone-beam computed tomography in orthodontics. J Am Dent Assoc. 2012;143(3):241-252.
[13] Celenk M, Farrell ML, Eren H, Kumar K, Singh GD, Lozanoff S. Upper airway detection and visualization from cone beam image slices. J Xray Sci Technol. 2010;18(2):121-135.
[14] Alves M Jr, Franzotti E S, Baratieri C, Nunes L K, Nojima L I, Ruellas A C 2012 Evaluation of pharyngeal airway space amongst different skeletal patterns. International Journal of Oral and Maxillofacial Surgery 41: 814–819 Battagel J M, L'Estrange P R 199
[15] The cephalometric morphology of patients with obstructive sleep apnoea (OSA). European Journal of Orthodontics 18: 557–569 Battagel J M, Johal A, Kotecha B 2000 A cephalometric comparison of subjects with snoring and obstructive sleep apnoea. European Journal of Orthodontics 22: 353–365
[16] Erwin Rojas, Rodrigo Corvalán, Eduardo Messen, Paulo Sandoval. Upper airway assessment in Orthodontics: a review 2017
[17] Periago DR, Scarfe WC, Moshiri M, Scheetz JP, Silveira AM, Farman AG. linear accuracy and reliability of cone beam CT derived 3-dimensional images constructed using an orthodontic volumetric rendering program. Angle Orthod 2008;78:387-95.
[18] Pinsky HM, Dyda S, Pinsky RW, Misch KA, Sarment DP. Accuracy of three-dimensional measurements using cone-beam CT. Dentomaxillofac Radiol 2006;35:410-6.
[19] Stratemann SA, Huang JC, Maki K, Miller AJ, Hatcher DC. Comparison of cone beam computed tomography imaging with physical measures. Dentomaxillofac Radiol 2008;37:80-93.
[20] yamashina A, Tanimoto K, Sutthiprapaporn P, Hayakawa y. The reliability of computed tomography (CT) values and dimensional measurements of the oropharyngeal region using cone beam CT: comparison with multidetector CT. Dentomaxillofac Radiol 2008;37:245-51.

[21] Valera FC, Travitzki LV, Mattar SE, et al. Muscular, functional and orthodontic changes in preschool children with enlarged adenoids and tonsils. J Pediatr Otorhinolaryngol. 2003;67:761–70.

[22] Pereira SRA, Bakor SL, Weckx LLM. Adenotonsillectomy in facial growing patients: spontaneous dental effects. Braz J Otorhinolaryngol. 2011;77(5): 600– 4.

[23] Knösel M, Nüser C, Jung K, Helms HJ, Engelke W, Sandoval P. Interaction between deglutition, tongue posture, and malocclusion: a comparison of intraoral compartment formation in subjects with neutral occlusion or different types of malocclusion. Angle Orthod. 2016;86(5):697–705.

[24] Sears CR, Miller AJ, Chang MK, Huang JC, Lee JS. Comparison of pharyngeal airway changes on plain radiography and cone-beam computed tomography after orthognathic surgery. J Oral Maxillofac Surg. 2011;69:e385–e394.

[25] Lenza MG, Lenza MM, Dalstra M, Melsen B, Cattaneo PM. An analysis of different approaches to the assessment of upper airway morphology: a CBCT study. Orthod Craniofac Res. 2010;13:96–105. 24. Kim YJ, Hong JS, Hwang YI, Park YH. Three-dimensional analysis of pharyngeal airway in preadolescent children with different anteroposterior skeletal patterns. Am J Orthod Dentofacial Orthop. 2010;137:306.e1–311.e1; discussion 306–307.