Lateral cephalometry: A simple and economical clinical guide for assessment of nasopharyngeal free airway space in mouth breathers

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Abstract

Nasopharyngeal obstruction by adenoid enlargement is one of the main causes of mouth breathing. Cephalometric radiographs and rhinomanometric tests to evaluate nasal obstruction have been available for several decades. Various lines and areas have been interpreted by number of investigators to implicate the enlarged adenoid in a casual relationship with mouth breathing and the subsequent effect on vertical facial growth. The aim of this paper is to review lateral cephalometric tracing methods combined with newer Auto-cad surface area measurement program so that assessment of the nasopharyngeal free airway space can be done based on it, before more rigorous ear-nose-throat follow up is needed for the patient.

Keywords: Auto-cad surface area measurement, lateral cephalometry, mouth breathing nasopharyngeal free airway space

Introduction

Ever since the time of Edward H. Angle, the effects of upper airway obstruction have been recognized in the field of craniofacial biology. The resulting relationship of variance in breathing pattern to dentofacial form continues to be debated even after a century of conjecture and intense argument.

The nasopharynx is a musculomembranous tube serving as a portal between the nasal chamber anteriorly and the oropharynx inferiorly. Its primary biologic function is to provide a passageway for air from the nasal chamber to the oropharynx, laryngeal pharynx, and ultimately to the lungs. The nasopharynx also provides space on its posterior and superior walls for lymphoid tissue in the form of nasopharyngeal tonsil as part of Waldeyer’s tonsillar ring. This tissue is often seen to hypertrophy during childhood and is denoted as “adenoids.” The enlargement of the adenoids may lead to partial or total blockage of the nasopharyngeal passage making nasal respiration either inefficient or impossible.[1]

The size of the nasopharyngeal airway is particularly important in determining whether the mode of breathing is nasal or oral.

The relationship between adenoids and neighboring structures can be well evaluated by a lateral cephalogram.

Adenoid tissue connection extends in various degrees from the roof and the posterior wall of nasopharynx to the posterior pharyngeal surface of the palate.

If an obstructed posterior upper airway causes problematic facial growth, which is still a topic of controversy,[2] then it would be beneficial to have a reliable diagnostic test to evaluate the need for treatment. However, diagnosing an obstructed posterior airway is not always a simple task because its location normally prevents direct observation. Several tools have been used for diagnosis including nasal resistance and airflow test, nasoendoscopy, lateral cephalometry, and three-dimensional imaging. Each possesses positive and negative qualities. However, there is no consensus on the gold standard procedure for diagnosing posterior airway obstruction. Most often nasal airway patency is not clearly established in the dental office, and ENT referrals are made mandatory to clearly establish it.

The lateral cephalogram, a standardized sagittal X-ray of head and neck, is perhaps the most commonly used of the above tests, especially in dentistry. It is a simple, economical, readily available, and reproducible way to diagnose upper airway obstruction. A high correlation has been found between the results of posterior rhinoscopy and the size of adenoids on the posterior nasopharyngeal wall seen on lateral radiographs.[2,3]

Hendelman and Linder-Aronson evaluated adenoid growth quantitatively in lateral cephalograms. They reported an increase in adenoid mass, at least in two dimensions, during preschool and beginning of school years, and also its degeneration at the prepubertal and pubertal periods.[1,4]

Bergland.[5] used a triangle based on three anatomic points, pterygomaxillary, hormion, and basion, to describe the bony nasopharynx. Linder Aronson[1] adapted Bergland’s analysis of the nasopharynx and measured the adenoids within the triangle using a planimeter.
The trapezoidal analysis method given by Handleman and Osborne\cite{1} proves to be good clinical guide for measuring nasopharyngeal area on lateral cephalogram. Moreover, with the advent of computerized tracing this can be converted into surface area measurement, thus enabling the clinician to measure expected obstruction. No such attempt has been made earlier in this context.

A clinical pilot study was therefore carried out by tracing certain reference points and lines combining them with surface area measurement with AutoCad tracing on lateral cephalograms of 30 mouth breathers, of 6-18 years of age in the Department of Pedodontia and preventive dentistry, Govt. Dental College, Amritsar, Punjab.

**Materials and Methods**

**Materials**
1. Standardized lateral cephalograms of 30 subjects were used.
2. 3-H lead pencil was used for tracing of radiographs.
3. Acetate paper was used.
4. Illuminated light box was used for tracing the radiograph
5. AutoCad software system.
6. Digital scanner

**Methodology**
* Standardization of Radiograph: All the lateral cephalometric radiographs were taken using a standardized technique, with the teeth in centric occlusion and lips relaxed. The subjects stood with the sagittal plane parallel to the film and the bilateral ear rods gently inserted into the external auditory meatus to stabilize the head position during exposure. The head was adjusted so that the Frankfort horizontal plane was parallel to the floor. The posterior limit of the nasopharynx is dependent upon the position of the anterior arch of atlas so the cephalometric radiograph should be taken in natural head position, because the atlas moves anteriorly or posteriorly with the extension or flexion of the cervical vertebrae.

* Tracing of Radiograph: Tracings were made of the lateral cephalograms taken in the intercuspal position. Tracings were made by the same person to avoid inter examiner variation, using a 3-H lead pencil on acetate paper over an illuminated light box. Traditional cephalometric points and contours were marked. Several linear and area measurements along with ratios were determined to evaluate the sizes of the adenoidal tissues and upper airway dimensions. To avoid personal variation, randomly selected 10 radiographs were re-traced by another experienced clinician.

**Reference points [Figure 1]**
The cephalometric reference points:
Ba (Basion) = the most postero-inferior point on the clivus of occipitale
Ptm (Pterygomaxillarey) = the intersection between the nasal floor and the posterior contour of the maxilla
S (Sella) = the centre of the sella turcica
So = the midpoint on the line joining Sella and basion
ad1 = the intersection of the line Ptm-Ba and the posterior nasopharyngeal wall
ad2 = the intersection of the posterior nasopharyngeal wall and the line Ptm-So.

**Reference lines [Figure 2]**
1. Palatal line (PL): Line representing palatal plane passing most superior point on Dens Axis
2. Anterior atlas line (AAL): Line perpendicular to palatal plane tangent to anterior surfaces of Dens Axis.
3. Pterygomaxillary line (PML): Line perpendicular to palatal plane that intersects palatal plane at ptetergomaxillary fissure.
4. Sphenoid line (SpL): Line tangent to lower border of sphenoid bone registered at basion.
The nasopharyngeal area (Np) area was derived mathematically by using formula given by Handelman CS, Osborne G.\[1\]

\[
\text{Np area} = \frac{d (h - d \tan \theta)}{2}
\]

Where 
- (Depth): The distance between pm and the intersection point of PL and AAL lines, measured in mm, signifies the anterior-posterior depth of nasopharynx. 
- (Height): The distance between pm and the intersection point of PML and SPL lines, measured in mm, represents the anterior height of the nasopharyngeal bony space. 
- (Theta angle): Sphenoid line/palatal line angle [Figure 3].

**Linear measurements**

The following measurements were made:

- \( \text{Ptm-ad1} = \) linear distance from the point Ptm to the point ad1, in mm
- \( \text{Ptm-ad2} = \) linear distance from the point Ptm to the point ad2, in mm

**Area measurements**

NP area (nasopharyngeal area): Corresponds to the nasopharyngeal bony area in vertical and antero-posterior dimensions, measured in \( \text{mm}^2 \) by using above formula [Figure 4].

**Digitalization of Image**

Air area was calculated using AutoCad software system by digitalizing the tracing image. Steps involved in calculation of air area are

**Step 1. Digitalization of image**

a. The tracing image is opened with the raster image reference in INSERT menu in the software.

b. The POLYLINE command is selected from side bar menu and image is marked with polyline.

c. The first and last selected points of the image are joined and closed area is formed representing air area.

**Step 2. Dimensioning the image**

Dimensioning is the process of adding measurement annotation to a drawing.

a. Click Dimension menu » Linear.

b. Press ENTER to select the object to dimension, or specify the first and second extension line origins.

c. Specify the dimension line location.

**Step 3. Calculation of the area**

a. Click Tools menu » Inquiry » Area.

b. At the command prompt, enter area.

c. Specify points in a sequence that defines the perimeter of the area to be measured. Then press ENTER.

The first and last points are connected to form a closed area and the area and perimeter measurements are displayed using the settings specified with UNITS [Figure 5].

**Ear, nose and throat examination**

All the subjects were referred to oto-rhinolaryngologist for complete ear, nose, and throat examination, and nasal obstruction score was obtained.
Discussion

When planning orthodontic therapy, it may be desirable to assess the ability of the patient to breathe through nose. It is therefore, of value to supplement clinical techniques for establishing the mode of breathing with this simple, objective method for estimating the size of nasopharyngeal airway.

The measured parameters from lateral cephalogram are divided into three parts
1. Linear measurement (ptm-ad1, ptm-ad2)
2. Area measurement (NP area, air area, adenoid area)
3. Depth (d) and height (h) of nasopharynx
4. Nasal obstruction score obtained by ENT examination.

The size of nasopharynx and its component areas, the airway, soft tissue pharyngeal wall, and the adenoids are quantified using lateral cephalometric radiographs. The nasopharynx for the purpose of analysis in this paper is a trapezoid formed by four planes which represent the skeletal limits of this region.[1] Berglands triangle does not fit the outline of the nasopharynx as adenoid tissue is found anterior to the triangle and basin has little direct influence on limits of the posterior pharyngeal wall. The trapezoid analysis used in this paper reflects better the limits of bony nasopharynx. Hence, the combination of Linder Aronson’s linear measurement and area measurement by trapezoid analysis given by Handelman CS, Osborne G.[1] was used in this study.

Unbalanced growth of adenoids and nasopharyngeal bony space (when nasopharyngeal bony space grows less than the adenoid tissue) will result in the obstruction of nasopharyngeal space and consequently mouth breathing begins.[6] The depth of nasopharynx when measured as the distance of PNS to basion should increase by 9% during the growth period and an antero-posterior stability will be produced during the first or second year of life.[1,7] The major part of nasopharyngeal growths occurs in a vertical direction, particularly caused by the downward growth of the palate and the growth effects of sphenoorbital synchondros which is also in the vertical direction. The size of nasopharynx increases with age during childhood and lymphoid tissue on the posterior wall of the nasopharynx usually diminishes during and after puberty (Todd, 1936).[8] It is therefore important to know the average antero-posterior size of nasopharyngeal airway at different ages.

The linear cephalometric measurement Ptm-ad2 seems to give the best information of the nasopharyngeal airway in a lateral radiograph when compared with nasoendoscopy (Oswaldo Vilella et al).[9] It was suggested that mouthbreathers should be referred for Ear-nose-throat examination of the nasopharyngeal airway if the cephalometric analysis of the nasopharyngeal airway shows Ptm-ad1 distances of < 9.9 mm at the age of 6–7 years, < 12.4 mm at the age of 8–9 years, or < 11.6 mm at the ages 10–11 years. The corresponding values for the Ptm-ad2 distance are < 8.6 mm (6–7 years), < 8.8 mm (8–9 years), or < 10.0 mm (10–11 years). For the air area the corresponding values are < 25.3 mm² (6–7 years), < 36.9 mm² (8–9 years), or < 35.5 mm² (10–11 years),[9] which coincided with our measurements.

For calculation of nasopharyngeal air-way space, the linear measurements and area measurements are used in this paper. This combination technique gives a dental clinician a fairly good measurement of nasopharyngeal airway space which allows them to clinically differentiate which subject should be referred for ENT check up prior to treatment and which subject can be taken up for interceptive treatment without ENT intervention.

Further research in this area should be towards supplementing the other nasorespiratory functional tests with this simple and economical method of diagnosing free airway space in upper airway obstructions.

Hence the greatest use of lateral cephalogram as a screening tool for diagnosing obstructed upper airways before more rigorous ear-nose-throat follow up is suggested.

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