Correlation between Subjective and Linear Measurements of The Palatal Airway on Lateral Cephalometric Radiography

Mohamed Abd El Aziz El Dab[1], Mohamed Abd El Mon'm Younis[1], Mohamed Ahmed El Sharkawy[1], Mohamed Abd El Razek Abd El Aziz[2], Ahmed Mohamed Anwar[*2]

[1]Otolaryngology, [2]Radiology, Faculty of Medicine Al-Azhar University,[3] Alexandria Faculty of Medicine

[*] Corresponding Author: Ahmed Mohamed Anwar, email: tantawy_wael@yahoo.com

ABSTRACT

Introduction: hypertrophied adenoid tissue is one of the most common health problems that occurs in childhood that results in many symptoms including 1. Nasal obstruction. 2. Mucoid, mucopurulent nasal discharge and postnasal discharge 3. Snoring and obstructive sleep apnea. 4. Recurrent acute otitis media (A.O.M).

Objective: to evaluate the correlation between subjective and linear measurements of palatal airway on lateral cephalographs. **Patients and Methods:** Diagnostic lateral cephalometric imaging study that took place from March 2017, to July 2018. 200 Children with chronic mouth breathing (116 boys and 84 girls), with age range from 2 to 14 years, were enrolled in this study. Patients were grouped into three groups according to age: a- 2 - <6 years were 84 patients (42%). b- 6 - <10 years were 76 patients (38%). c- 10 – 14 years were 40 patients (20 %).

Results: The age was inversely correlated with the grade of airway obstruction. The correlations between the palatal airway grading with the shortest adenoid distance (SAD) and the most convex adenoid distance (CAD) were r= -0.826 and r= -0.424, respectively, which is statistically significant. The relation between SAD and CAD was directly proportional to each other accounting for correspondence of evaluation in more than 50% of the population which is statistically significant. **Conclusion:** subjective grading of palatal airway obstruction correlates with the objective measurements of SAD and CAD. Although both methods are reliable in measurement particularly the more severe obstructions, SAD is a more favorable objective tool.

Keywords: hypertrophied adenoid, CAD, SAD.

INTRODUCTION

The pharynx forms the common upper pathway of the respiratory and alimentary tracts. It extends from the skull base to the lower border of the cricoid cartilage. It communicates with the nasal cavity as nasopharynx, the mouth as oropharynx and the larynx as hypopharynx [(1)]. Waldeyer’s ring is a ring of lymphoid tissues surrounding the pharynx, where nasal and oral passages unite. It consists of four main masses of lymphoid tissue, namely the palatine tonsils, the lingual tonsils, the pharyngeal tonsils (more commonly referred to as adenoids), and the tubal tonsils, forming a ring of lymphoid tissue) [(2)]. The pharyngeal (tonsils) adenoid is the lobulated masses of lymphoid tissues in the roof of nasopharynx. It represents primary immunologic tissues, which represents the first line of defense against foreign-based pathogens whose principal port of entry is through the respiratory tract. Adenoid captures and entraps foreign materials that are inhaled, resulting in exposure of antigenic material that leads to activation of immune responses and subsequent hyperplasia of these tissues. The lymphatic tissue is similar to that of the palatine tonsils [(3)].

In newborns, the neck is relatively short, and the infant larynx is positioned high, approximating the third or fourth cervical vertebrae at rest, while rising to the height of the first or second cervical vertebrae with swallowing [(4)]. The higher located larynx allows potential overlap of the soft palate and the epiglottis, establishing a secure airway during oral nutritive sucking, thus permitting the infant to eat and breathe at the same time [(5)]. The soft palate overlapping the epiglottis contributes significantly to the preferential nasal breather status that characterizes infancy. These anatomic features of the larynx predispose the infant for rapid aggravation of upper airway obstruction. With growth of the neck, the larynx gradually descends to the adult position, at or near the fourth or fifth cervical vertebrae[(1, 2)].

Compared with the nasopharynx and oropharynx in adults, these structures in children normally have more lymphoid tissues within the mucosa, extending into the airway [(6)].

Clinical picture of adenoid hypertrophy:

The clinical symptoms of adenoid enlargement vary with the age of the patient and can be associated with the patient's general condition as well as with the size of the nasopharynx. Thus in a small nasopharynx, the adenoid tissue may prove to be clinically significant whereas a larger adenoid mass may be relatively asymptomatic in an anatomically larger nasopharynx. In normal children the size and shape of the adenoid tissue varies from year to year and the anterior convexity changes to a concavity with maturity. The adenoid appears to grow more rapidly between 3 and 5 years of age. Therefore, it's important to perform further assessment of the size of the adenoid in different age groups. The most common symptoms attributed to adenoid enlargement are: 1. Nasal obstruction which results into: a. Mouth breathing b. Adenoid facies c. Hypo-nasality of voice. 2. Mucoid, mucopurulent nasal discharge and

Received:23/1/2019
Accepted:23/2/2019

postnasal discharge 3. Snoring and obstructive sleep apnea. 4. Recurrent A.O.M and CSOM. 5. Effects of enlarged adenoids on the general health of the child: There may be dull general appearance, lack of chest development, and a suggestion of chronic illness. Also frequent headaches, upper respiratory tract infections, gastrointestinal upsets and personality disturbances may occur [7].

PATIENTS AND METHODS

200 Children with chronic mouth breathing (116 boys and 84 girls), with age range of 2 to 14 years, were enrolled in this study and were assessed by lateral cephalographs. **Ethical approval of the Ethical Committee of the Faculty of Medicine Al-Azhar Universty was taken. Consent of the patients' parents that their children will be enrolled in this study was taken.**

Inclusion criteria: (1) children 2-14 years old. **(2)** Chronic mouth breather > 3 months duration.

Exclusion criteria: **(1)** Previous adenoidectomy. **(2)** Anatomic anomaly in the nose, palate, or nasopharynx. **(3)** Acute infection.

Patients were grouped into three groups according to age: **a-** 2 - <6 years were 84 patients (42%). **b-** 6 - <10 years were 76 patients (38%). **c-** 10 – 14 years were 40 patients (20 %).

Palatal airway assessment

Two methods were used to quantify the palatal airway: a grading system based on direct observation and linear measurements

The palatal airway was graded subjectively as: grade 1 (less than 50% obstruction), grade 2 (50%-75%), and grade 3 (more than 75%). **(Figure 1)**

(a)

(b)

(c)

Figure 1. Lateral cephalographs of 3 children with chronic mouth breathing: images show different grades of airway obstruction relative to adenoid size. A, 11 years old boy with grade 3 obstruction with adenoid facies. B, 8 years old girl with grade 2 obstruction. C, Grade 1 obstruction in 10 years old girl.

Two linear measurements between the adenoid and soft palate on the lateral cephalograph were used to assess the patency of the palatal airway, the shortest adenoid distance (SAD), and the most convex adenoid distance (CAD). **(Figure 2)**

Figure 2. Linear measurements of the palatal airway (between adenoid and soft palate). A, Most convex adenoid distance (CAD). B, Shortest adenoid distance (SAD). [8]

Statistical analysis of the data

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level.

The used tests were:

1 - Chi-square test

For categorical variables, to compare between

different groups
2 – Kruskal Wallis test
For abnormally distributed quantitative variables, to compare between more than two the studied groups, and Post Hoc (Dunn's multiple comparisons test) for pairwise comparisons
3 - Spearman coefficient
To correlate between two distributed abnormally quantitative variables.

RESULTS

200 Children with chronic mouth breathing (116 boys and 84 girls), with a mean age of 7.37 years and an age range of 2 to 14 years, were enrolled in this study**,** most patients (80%) were younger than 10 years, with 84 patients (42%) younger than 6 years. The mean SAD was 3.41 mm (range: 0.2 – 10 mm), and the mean CAD was 3.7 mm (range: 1- 7 mm).

Most patients had grade 3 obstruction (52%), followed by grade 2 (34%) and grade 1 (14%). The age was inversely correlated with the grade of airway obstruction, with a mean age of 5.92 years in those with grade 3 obstruction, 8.3 years in those with grade 2 obstruction, and 11.14 years in those with grade 1 obstruction which is statistically significant.

For SAD, a mean of 1.72 mm (range: 0.2 – 4 mm) was found in grade 3 obstruction, 4.53 mm (range: 2 – 7 mm) in grade 2 obstruction, and 7 mm (range: 6 -10 mm) in grade 1 obstruction. The prevalence of the lowest SAD measurements (0-2 mm), which encompassed most of the patients with grade 3 obstruction (76.9 %) but also some of those with grade 2 (5.9 %), was highest at the younger ages which is statistically significant **(Table 1).**

Table (1): Comparison between obstruction grades according to SAD

SAD	Obstruction grade						Test of sig.	p
	I (n= 28)		II (n= 68)		III (n= 104)			
	No.	%	No.	%	No.	%		
≤ 2 > 2	0 28	0.0 100.0	4 64	5.9 94.1	80 24	76.9 23.1	[illegible]	$<0.001^*$
Sig.bet.Grps	$^{FE}p_1=0.318, p_2<0.001^*, p_3<0.001^*$							
Min. – Max. Mean ± SD. Median	6.0 – 10.0 7.0 ± 1.44 6.0		2.0 – 7.0 4.53 ± 1.34 4.0		0.20 – 4.0 1.72 ± 1.16 1.50		$H= 135.666^*$	$<0.001^*$
Sig.bet.Grps	$p_1<0.001^*, p_2<0.001^*, p_3<0.001^*$							

χ^2: **Chi square test** FE**: Fisher Exact**
H: H for **Kruskal Wallis test,** Pairwise comparison bet. each 2 groups was done using **Post Hoc Test (Dunn's for multiple comparisons test)**
p: p value for comparing between the studied groups
p_1: p value for comparing between I and II
p_2: p value for comparing between I and III
p_3: p value for comparing between II and II
*: Statistically significant at $p \le 0.05$

Table (2): Comparison between obstruction grades according to CAD

CAD	Obstruction grade			H	p
	I (n= 28)	II (n= 68)	III (n= 104)		
Min. – Max. Mean ± SD. Median	4.0 – 7.0 5.57 ± 1.07 5.0	2.0 – 6.0 3.65 ± 1.19 3.0	1.0 – 6.0 3.23 ± 1.29 3.50	50.196^*	$<0.001^*$
Sig.bet.Grps	$p_1<0.001^*, p_2<0.001^*, p_3<0.001^*$				

H: H for **Kruskal Wallis test,** Pairwise comparison bet. each 2 groups was done using **Post Hoc Test (Dunn's for multiple comparisons test)**
p: p value for comparing between the studied groups
p_1: p value for comparing between I and II
p_2: p value for comparing between I and III
p_3: p value for comparing between II and II
*: Statistically significant at $p \le 0.05$

For CAD a mean of 3.23 mm (range, 1 – 6 mm) was found in grade 3 obstruction, 3.65 mm (range, 2 – 6 mm) in grade 2 obstruction, and 5.57 mm (range, 4 – 7 mm) in grade 1 obstruction which is statistically significant. **(Table 2).**

Table (3): Correlation between obstruction grade with CAD and SAD (n= 200)

	Obstruction grade	
	r	**p**
CAD	-0.424*	<0.001*
SAD	-0.826*	<0.001*

r: Spearman coefficient
*: Statistically significant at p ≤ 0.05

The palatal airway grading correlations with SAD and CAD measurements were $r = -0.826$ and $r = -0.424$, respectively, accounting for correspondence of evaluation in more than 50% of the population which is statistically significant. There is also an inverse relation between obstruction grade compared to SAD and CAD **(Table 3).**

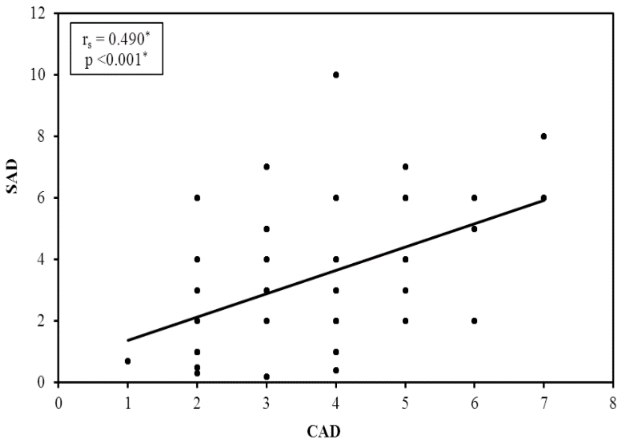

Figure 3: Correlation between CAD and SAD (n= 200)

The relation between SAD and CAD was directly proportional to each other accounting for correspondence of evaluation in more than 50% of the population which is statistically significant **(Figure 3)**.

DISCUSSION

Over the past few decades, obstructive sleep apnea (OSA), a life-threatening disorder, has become recognized as the most extreme variety of mouth breathing on the wide spectrum of upper airway obstruction. Thus, early diagnosis and treatment of children with OSA is indicated to normalize breathing function. The major cause of OSA in children is adenotonsillar hypertrophy and the severity of OSA is associated with the size of the hypertrophic adenoids [9]. Sleep breathing disorders are characterized by prolonged increased upper airway resistance, partial upper airway obstruction, or complete obstruction that disrupts pulmonary ventilation, oxygenation, or sleep quality. Snoring is the most common nighttime symptom in children [10].

Other symptoms associated with sleep breathing disorders can include restless sleep, frequent arousals, snoring, gasping, unusual sleeping positions (e.g., sitting), sweating during sleep, and nocturnal enuresis [11].

The most prominent daytime symptom of sleep-disordered breathing in adults is excessive daytime sleepiness [12].

Otolaryngologists and orthodontists are concerned with nasal obstruction because it may lead to morphologic characteristics that affect facial pattern and dental occlusion. The present findings underscore the importance of early diagnosis through an important methods of evaluation: the cephalometric linear measurements provide a reliable objective method, closely followed by the more subjective rating system [8].

Multiple methods to evaluate adenoid tissue and its correlation to the nasopharyngeal airway were invented. Lateral nasopharyngeal x-ray and nasal endoscopy are commonly used to evaluate the size of adenoid tissues. However, there is not much consensus over the best way of grading the size and position of adenoid tissue in preoperative period. Nasal endoscopy is a safe, dependable, and simply tolerated diagnostic method if proper endoscopes are used under suitable conditions. It gives highly objective and correct results. However, evaluation of the images obtained during nasal endoscopy shows variations. However, this method is sometimes difficult to perform to pediatric patients. They are difficult to tolerate and can be afraid from it. Therefore, lateral nasopharyngeal x-ray graphs are important for pediatricians. Lateral nasopharyngeal x-ray graphs are generally used by pediatricians and otolaryngologist specialists to estimate adenoid tissue in clinics. This method is easy to perform and tolerable especially in pediatric patients [13].

In this study, we divided the patients into 3 groups according to age in a 4-year interval (2-<6, 6-<10, 10 -14). Each child was assessed by their own complains and their parents to correlate their words to the findings of the lateral cephalometry, which is further assessed subjectively and objectively.

Subjectively, we divided the obstruction made by the hypertrophied adenoid into 3 grades (I, II and III) and correlate them to subjective linear measurements CAD and SAD as in **Souki *et al.*** [9].

In this study we found that most of patients are with grade 3(52%) obstruction, but in **Bitar *et al.*** [8] study they found that most of patients are of grade 2 obstruction (60.5%). In both studies there is an inverse relation between age and obstruction grade.

The present study showed that the distances between the adenoid and soft palate (SAD and CAD), were correlated highly with each other ($r = 0.49$), also had good correlations with the observational rating ($r = -0.826$ and $r = -0.424$, respectively) as in **Bitar *et al.*** [8].

In contra verse **Wormald and Prescott [14]** found that a simple linear measure of adenoid size did not correlate well (r = 0.34) against degree of nasopharyngeal obstruction, which may be due to dependence on endoscopic assessment where they compared endoscopic with radiological assessment of adenoid size, not like the present study, which depended on radiological assessment.

Other studies search the relation between the adenoid area in relation to the subjectively graded obstruction. For example, both **Jeans *et al.* [6]** and **Maw *et al.* [15]** found that nasopharyngeal soft-tissue areas in radiographs had good correlations with actual tissue volumes removed during adenoidectomy (r = 0.7-0.74). Similarly, **Holmberg and Linder-Aronson [16] and Linder-Aronson *et al.* [17]** found fair correlations of radiographic adenoid areas to subjectively graded adenoid sizes during endoscopy (r = 0.60).

Because no study or clinical experience suggests that the adenoid is the only obstacle to airway obstruction in any single patient, a clearance of 0 to 2 mm in SAD is considered close to full obstruction. Therefore, in these patients, the role of the adenoid in the impairment of nasal breathing would be primary and consequently the removal of the tissue recommended if accompanied by early signs of facial dysmorphologic features. Clearly, if other reasons are also identified, adenoidectomy would be part of the treatment strategy[8].

In this study, we also found that the obstruction grade is inversely proportional to the age as in **Bitar *et al.*[8] and Macari *et al.* [18]**, this is probably due to anatomic changes during growing as the distance between the adenoid and soft palate increases with age.

Because SAD is a more objective way to measure palatal airway patency and because a SAD less than or equal to 2 mm included most patients with grade 3 obstruction (80%) and some of those with grade 2 obstruction (with more severe obstruction), we advocate the use of SAD for evaluation.

REFERENCES

1- **Adewale L (2009):** Anatomy and assessment of the pediatric airway. Pediatric Anesthesia, 19(1): 1-8.

2- **Gozal D, Kheirandish-Gozal L (2012):** Lymphadenoid tissues in the upper airway. In: Jinkwan Kim , David Gozal, editor. Sleep disordered breathing in children: a comprehensive clinical guide to evaluation and treatment. Springer Science & Business Media, 12: 25-36.

3- **Hollinshead W (1982):** The pharynx and larynx. In: De Caville J Wr, Bedard R, editor. Anatomy for surgeons. Vol. 1. 3rd ed: Philadelphia: Lippincott.

4- **Isaacson G (2003):** Developmental anatomy and physiology of the larynx, trachea, and esophagus. In: Bluestone Cd, Stool Se, Alper Cm, et al., editor. Pediatric otolaryngology. Vol. 2: Philadelphia: WB Saunders.

5- **Petkar N, Georgalas C and Bhattacharyya A (2007):** High-rising epiglottis in children: should it cause concern? The Journal of the American Board of Family Medicine,20(5):495-6.

6- **Jeans W, Fernando D, Maw A *et al.* (1981):** a longitudinal study of the growth of the nasopharynx and its contents in normal children. The British Journal of Radiology, 54(638):117-21.

7- **Reid JM, Donaldson JA (1970):** The indication for tonsillectomy and adenoidectomy. Otolaryngol Clin North Am., 3:339-44.

8- **Bitar MA, Macari AT and Ghafari JG (2010):** Correspondence between subjective and linear measurements of the palatal airway on lateral cephalometric radiographs. Archives of Otolaryngology Head & Neck Surgery, 136(1): 43-47.

9- **Souki M, Souki B, Franco L *et al.* (2012):** Reliability of subjective, linear, ratio and area cephalometric measurements in assessing adenoid hypertrophy among different age groups. The Angle Orthodontist, 82(6):1001-1007.

10- **Carroll JL (2003):** Obstructive sleep-disordered breathing in children: new Controversies, new directions. Clin Chest Med., 24:261-82.

11- **Chervin RD, Archbold KH, Dillon JE *et al*. (2002):** Inattention, hyperactivity, and symptoms of sleep-disordered Breathing. Pediatrics, 109:449-56.

12- **Carroll JL, Mccolley SA, Marcus CL *et al.* (1995):** Inability of clinical history to distinguish primary snoring from obstructive Sleep apnea syndrome in children. Chest, 108: 610-8

13- **Acar M, Kankilic E, Koksal A *et al.* (2014):** Method of the diagnosis of adenoid hypertrophy for physicians. The Journal of Craniofacial Surgery, 25(5): 438-440.

14- **Wormald PJ, Prescott CA (1992):** Adenoids: comparison of radiological assessment methods with clinical and endoscopic findings. J Laryngol Otol., 106:342-4.

15- **Maw AR, Jeans WD and Fernando DC (1981):** Inter-observer variability in the clinical and radiological assessment of adenoid size, and the correlation with adenoid volume. Clin Otolaryngol., 6:317-22.

16- **Holmberg H, Linder-Aronson S (1979):** Cephalometric radiographs as a means of evaluating the capacity of the nasal and nasopharyngeal airway. Am J Orthod., 76:479-90.

17- **Linder-Aronson S, Woodside DG and Lundstrom A (1986):** Mandibular growth direction following adenoidectomy. Am J Orthod., 89:273-84.

18- **Macari AT, Bitar MA and Ghafari JG (2012):** New insights on age- related association between nasopharyngeal airway clearance and facial morphology. Orthodontics & Craniofacial Research, 15(3): 188-197.