Adenoid Hypertrophy: Correlation between Clinical and Radiological Findings

*Haque MA,[1] Asad MK,[2] Mahmud M,[3] Islam MR,[4] Islam MM,[5] Akanda MH,[6] Reza SS[7]

Abstract

Background: Adenoids, part of Waldeyer's ring, play a key role in immune defense. Adenoid hypertrophy (AH) is a common pediatric condition that can cause otitis media, sleep apnoea, cognitive and craniofacial complications if untreated. As the nasopharynx is not directly visible, AH is commonly assessed using clinical and radiological methods.

Objective: To determine the correlation between clinical assessment and grading of AH with radiographic findings in children diagnosed with AH.

Methods: This observational, cross-sectional study was conducted in the Department of Otolaryngology – Head & Neck Surgery, Chittagong Medical College Hospital, Chattogram, Bangladesh, from June 2022 to August 2023. Fifty pediatric patients with adenoid hypertrophy were selected consecutively using purposive sampling. Clinical scoring of mouth breathing/dyspnoea, sleep apnoea, and snoring was categorized as mild, moderate, or severe and compared with lateral nasopharyngeal radiographs assessed by Fujioka and Cohen methods. Data were analyzed in SPSS v26, with results expressed as mean ± SD, frequency, and percentage, and associations tested using ANOVA ($P < 0.05$).

Results: Among 50 children with adenoid hypertrophy (mean age 5.94 ± 0.72 years; 78% male), common clinical features were mouth breathing/dyspnoea (62%), snoring (58%), and apnoea (76%). Fujioka ANR ratios were mild 10%, moderate 58%, severe 32%, correlating with clinical severity ($P = 0.0017$; ROC cut-off 0.61: 76% sensitivity, 79% specificity). Cohen AC:SP ratios were mild 14%, moderate 62%, severe 24%, also correlating with clinical grading ($P = 0.0261$; ROC cut-off 0.66: 68% sensitivity, 57% specificity). Fujioka method showed higher reliability than Cohen.

Conclusion: Lateral radiographs of the nasopharynx are reliable and valid for evaluating children with AH in accordance with their clinical symptoms or grading. A strong correlation between clinical scores and radiological findings was observed. The Fujioka method demonstrated better accuracy than the Cohen method in terms of diagnostic validity and reliability.

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1. **Dr. Md. Aminul Haque, Junior Consultant (ENT), Department of ENT, Shaheed Syed Nazrul Islam Medical College Hospital, Kishoreganj, Bangladesh.* aminul49rmc@gmail.com.
2. *Professor Dr. Md. Khalid Asad, Department of ENT, Shaheed Syed Nazrul Islam Medical College, Kishoreganj, Bangladesh*
3. *Dr. Muddassir Mahmud, Assistant Professor (ENT), Department of ENT, Shaheed Syed Nazrul Islam Medical College, Kishoreganj, Bangladesh*
4. *Dr. Muhammad Rafiqul Islam, Assistant Professor (ENT), Department of ENT, Shaheed Syed Nazrul Islam Medical College, Kishoreganj, Bangladesh*
5. *Dr. Md. Mizanul Islam, Assistant Registrar (ENT), Department of ENT, Shaheed Syed Nazrul Islam Medical College Hospital, Kishoreganj, Bangladesh*
6. *Dr. Md. Mobarak Hosen Akanda, Registrar (ENT), Department of ENT, Mymensingh Medical College Hospital, Mymensingh, Bangladesh*
7. *Dr. SM Shohan Reza, Registrar (ENT), Department of ENT, Universal Medical College & Hospital, Dhaka, Bangladesh*

**For correspondence*

Introduction

Adenoids, also known as nasopharyngeal tonsils, are normal lymphoid tissues located at the junction of the roof and posterior wall of the nasopharynx, forming a part of Waldeyer's lymphatic ring at the entry of the upper respiratory tract. They play an important role in immune system development, acting as a first line of defense against respiratory and digestive antigens. Waldeyer's lymphatic ring also includes the faucial (palatine) tonsils, lingual tonsils, tubal tonsils, and subepithelial lymphoid tissue of the posterior pharyngeal wall. Similar to palatine tonsils, adenoids are comprised of mucosa-associated lymphoid tissue (MALT) containing germinal centers, though their crypt structure is less pronounced. The adenoids receive blood supply primarily from the ascending pharyngeal artery, with contributions from the internal maxillary and facial arteries, and sensory innervation from the glossopharyngeal and vagus nerves.[1,2]

Adenoid hypertrophy (AH) is defined as the abnormal enlargement of adenoids, leading to obstruction of the nasopharyngeal airway. It was first described by Danish physician Wilhelm Meyer in 1868, who linked chronic AH to nasal airway obstruction and proposed a surgical treatment through the anterior nostrils.[2,3] Adenoid hypertrophy commonly affects children, particularly between 1 to 6 years of age, with the prevalence decreasing during adolescence as adenoids naturally atrophy.[4,5] AH may result from infectious and non-infectious causes, including viral pathogens such as Adenovirus, Coronavirus, Cytomegalovirus, Epstein-Barr virus, and bacterial pathogens like Streptococcus species, Haemophilus Influenzae, and Moraxella Catarrhalis. Non-infectious factors include allergies, gastroesophageal reflux, cigarette smoke exposure, immune reactions, genetic and hormonal factors.[2,6,7]

Clinically, AH manifests with nasal obstruction, leading to mouth breathing, snoring, sleep apnoea, hyponasal speech, recurrent otitis media, and Eustachian tube dysfunction. Prolonged obstruction may cause complications such as neurocognitive deficits, cardiovascular morbidity, and characteristic facial features termed as adenoid facies, including a high-arched palate, pinched nostrils, elongated face, and crowded upper teeth.[1,8] Tonsillar hypertrophy may present with similar symptoms, and Brodsky grading is commonly used to classify tonsil size.[9] Epidemiological studies in Bangladesh reported a prevalence of AH among children of 9.1%, with 95% of radiologically confirmed cases being symptomatic.[10]

Adenoidectomy, often performed along with tonsillectomy, is a common pediatric surgical procedure. However, careful patient selection is necessary due to the immunological role of adenoids and potential surgical complications. Preoperative evaluation is essential but challenging, as the adenoids' anatomical location prevents direct visualization. Clinical assessment remains the first-line tool, but its reliability in young children is variable. Several indirect methods exist for evaluating AH, including lateral radiographs, nasopharyngoscopy, acoustic rhinometry, polysomnography, and MRI. Among these, lateral nasopharyngeal radiographs are inexpensive, widely available, reproducible, and well-tolerated by children, providing objective assessment of adenoid size, shape, and position.[11-14] Radiographs also help predict complications of AH such as corpulmonale, otitis media with effusion, and Eustachian tube dysfunction.[15,16]

Various radiographic methods have been developed to assess AH on lateral neck X-rays, including Fujioka et al.[17], Cohen et al.[18], Jóhannesson et al.[19], Crepeau et al.[20], and Mlynarek et al.[21] methods, among which

Fujioka and Cohen are widely used and reliable. Despite the availability of multiple diagnostic modalities, there is no universal consensus on the ideal assessment method. Thus, investigating the correlation between clinical scoring and radiographic grading of AH is essential to provide objective evaluation and guide surgical decision-making. This study aimed to determine the correlation between the clinical score of adenoid hypertrophy and radiological findings using Fujioka and Cohen methods.

Objective

To determine the correlation between clinical assessment and grading of AH with radiographic findings in children diagnosed with AH.

Methods

This observational, cross-sectional study was conducted at the Department of Otolaryngology and Head-Neck Surgery, Chittagong Medical College Hospital (CMCH), Chattogram, Bangladesh, from June 2022 to August 2023, for a period of 15 months. A total of 50 pediatric patients, aged 3–12 years, diagnosed with adenoid hypertrophy (AH) were included in the study. Patients were selected consecutively using purposive sampling based on predefined inclusion and exclusion criteria to evaluate the correlation between clinical assessment and radiographic grading of AH.

Children aged 3–12 years admitted with a clinical diagnosis of AH from the outpatient department for adenoidectomy were included. Symptomatic AH, including mouth breathing, snoring, sleep apnoea, hearing impairment, or lack of concentration was also considered. Patients were excluded if they were aged below 3 or above 12 years, had grossly enlarged tonsils or tonsillar hypertrophy (Brodsky grade >2), congenital craniofacial anomalies, active upper respiratory tract infection, septal deviation, or allergic rhinitis.

After obtaining informed written consent from parents or legal guardians, detailed history, demographic data, and ENT/systemic examinations were performed. Clinical symptoms persisting for more than two weeks were assessed and scored according to the Sharifkashani et al., 2015 system for mouth breathing/dyspnoea, snoring, and sleep apnoea. Clinical scores were calculated using the formula: $1.42D + 1.41A + 0.71S - 3.83$ and categorized as Mild (<−1), Moderate (−1 to 3.5), and Severe (>3.5). Adenoid facies and other characteristic features were noted, while hearing impairment was excluded due to the need for specialized testing.

All patients underwent lateral nasopharyngeal X-rays with an open mouth, protruded tongue, and slight neck extension. Radiographs were evaluated by the investigator using the Fujioka method (Adenoid Nasopharyngeal Ratio: Mild 25–50%, Moderate 50–75%, Severe ≥75%) and Cohen method (Air Column to Soft Palate ratio: Mild >0.81–1, Moderate >0.5–0.8, Severe ≤0.5). Clinical findings were compared with radiological measurements.

Independent variables included age, sex, residence, socioeconomic status, and clinical symptoms, while dependent variables were clinical score and radiographic scores from Fujioka and Cohen methods. Data were analyzed using SPSS v26.0. Qualitative data were expressed as frequency and percentage, and quantitative data as mean ± standard deviation. Associations between clinical and radiographic scores were examined using cross-tabulation and ANOVA. Diagnostic performance metrics including sensitivity, specificity, positive predictive value, negative predictive value, and accuracy were calculated using 2×2 contingency tables. A P-value <0.05 was considered statistically significant.

The study was conducted under close supervision with a pretested questionnaire and detailed work manual to ensure quality. Ethical approval was obtained from the Ethical Review Committee of CMCH. Voluntary informed consent was obtained from guardians and participant confidentiality, minimal risk, and ethical standards were maintained throughout the study.

Results

This observational cross-sectional study was carried out in the Department of Otolaryngology and Head-Neck Surgery at Chittagong Medical College Hospital, Chattogram, to determine the correlation between clinical assessment and grading of adenoid hypertrophy (AH) and lateral neck radiographic findings in children diagnosed with AH. According to the sample size formula, 55 participants were required; however, a total of 50 cases were finally analyzed. The results and observations are presented below.

Table I: Age Distribution of the Study Population (n = 50)

Age (years)	Frequency	Percentage (%)	Mean ± SD
3–5	27	54.0	
6–8	15	30.0	5.94 ± 0.72
9–12	8	16.0	

The majority of patients (54.0%) were aged 3–5 years, followed by 30.0% in the 6–8 years age group, and 16.0% in the 9–12 years age group. The overall mean age of the patients was 5.94 ± 0.72 years.

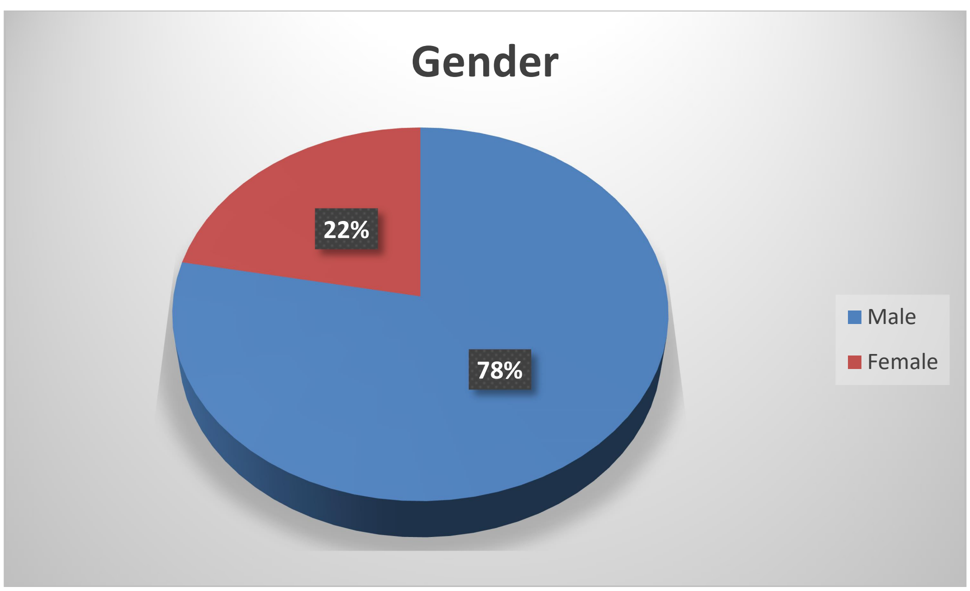

Figure 1. Gender Distribution of the Study Population (n = 50)

Out of 50 patients, 39 (78.0%) were male and 11 (22.0%) were female, resulting in a male-to-female ratio of 3.5:1.

Table II: Distribution of Respondents by Clinical Symptoms Scoring (n = 50)

Clinical Symptom	Grade 0 (Never/No)	Grade 1 (Occasionally)	Grade 2 (Frequently)	Grade 3 (Always)
Mouth breathing / Dyspnoea (D)	0 (0.0)	12 (24.0%)	31 (62.0%)	7 (14.0%)
Snoring (S)	4 (8.0%)	5 (10.0%)	29 (58.0%)	12 (24.0%)
Apnea (A)	12 (24.0%)	38 (76.0%)	—	—

Apnea was noted in 38 (76.0%) children. Most patients had Grade 2 mouth breathing/dyspnoea and snoring, accounting for 62.0% and 58.0%, respectively.

Table III: Radiological Findings of Adenoid Hypertrophy According to Fujioka Method (n = 50)

ANR Ratio	Frequency	Percentage (%)
25 to <50% (Mild)	5	10.0
50 to <75% (Moderate)	29	58.0
>75% (Severe)	16	32.0

According to the Fujioka method, the Adenoid Nasopharynx Ratio (ANR) was measured based on the operational definition. ANR of 25 to <50% was observed in 5 (10.0%) patients, 50 to <75% in 29 (58.0%) patients, and >75% in 16 (32.0%) patients.

Table IV: Correlation of Clinical Score with Radiological Findings by Fujioka Method (n = 50)

ANR Ratio	Clinical Score: Mild (n=4)	Clinical Score: Moderate (n=33)	Clinical Score: Severe (n=13)	P-value
25 to <50% (n=5)	4 (80.0%)	1 (20.0%)	0	—
50 to <75% (n=29)	0	28 (96.5%)	1 (3.5%)	0.0017
>75% (n=16)	0	4 (25.0%)	12 (75.0%)	—

Summary of Data by ANR Group (%)	Mild	Moderate	Severe	Total
$\sum X$	26	43	31	100
Mean	38.7	65.2	86.09	61.871
$\sum X^2$	293	1206	762	3068
Std. Dev.	9.486	10.54	10.22	9.862

One-Way ANOVA was used to compare the groups. Among patients with mild ANR ratio, 4 (80.0%) correlated with the mild clinical score; among moderate ANR ratio, 28 (96.5%) correlated with the moderate clinical score; and among severe ANR ratio, 12 (75.0%) correlated with the severe clinical score. The f-ratio value was 0.08642, and the result was statistically significant ($P = 0.0017$, $P < 0.05$).

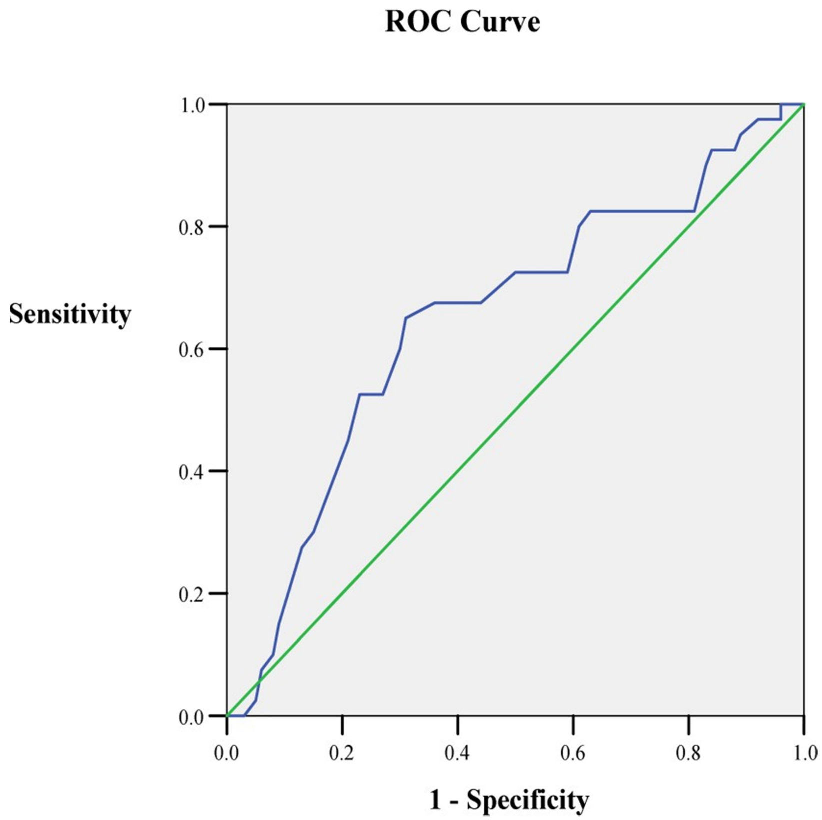

Figure 2. Receiver-Operator Characteristic (ROC) Curve of ANR Ratio for Prediction of Severity of Adenoid Hypertrophy (AH)

	Cut-off Value	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)	95% Confidence Interval (CI)
ANR Ratio	0.61	76.19	78.95	80	75	0.668–0.866

The table presents the Receiver-Operator Characteristic (ROC) curve analysis of the ANR ratio for predicting the severity of adenoid hypertrophy (AH). Using a cut-off value of 0.61, the ANR ratio demonstrated 76.19% sensitivity, 78.95% specificity, 80.0% positive predictive value (PPV), and 75.0% negative predictive value (NPV).

Table V: Radiological Findings of Adenoid Hypertrophy According to Cohen Method (n = 50)

AC:SP Ratio (AC to SP)	Frequency	Percentage (%)
>0.81 to ≤1 (Mild)	7	14.0
>0.5 to ≤0.8 (Moderate)	31	62.0
≤0.5 (Severe)	12	24.0

Radiological assessment using the Cohen method measured the AC:SP (Air Column to Soft Palate) ratio. A ratio of >0.81 to ≤1 was observed in 7 (14.0%) patients, >0.5 to ≤0.8 in 31 (62.0%) patients, and ≤0.5 in 12 (24.0%) patients.

Table VI: Correlation of Clinical Score with Radiological Findings by Cohen Method (n = 50)

AC:SP Ratio (AC to SP)	Clinical Score: Mild (n=4)	Clinical Score: Moderate (n=33)	Clinical Score: Severe (n=13)	p-value
>0.81 to ≤1 (n=7)	4 (57.1%)	2 (28.5%)	1 (14.3%)	0.0261
>0.5 to ≤0.8 (n=31)	0	26 (83.8%)	5 (16.2%)	
≤0.5 (n=12)	0	5 (41.7%)	7 (58.3%)	

Summary Data of AC:SP Group (%)	Mild	Moderate	Severe	Total
∑X	30	28	42	100
Mean	0.92	0.69	0.38	0.6632
∑X²	538	1685	845	3068
Std. Dev.	0.01	0.05	0.01	0.01083

One-Way ANOVA was used to compare the groups. Among patients with mild AC:SP ratio, 4 (57.1%) correlated with mild clinical scores; among moderate AC:SP ratio, 26 (83.8%) correlated with moderate clinical scores; and among severe AC:SP ratio, 7 (58.4%) correlated with severe clinical scores. The f-ratio value was 0.00927, and the result was statistically significant ($P = 0.0261$, $P < 0.05$).

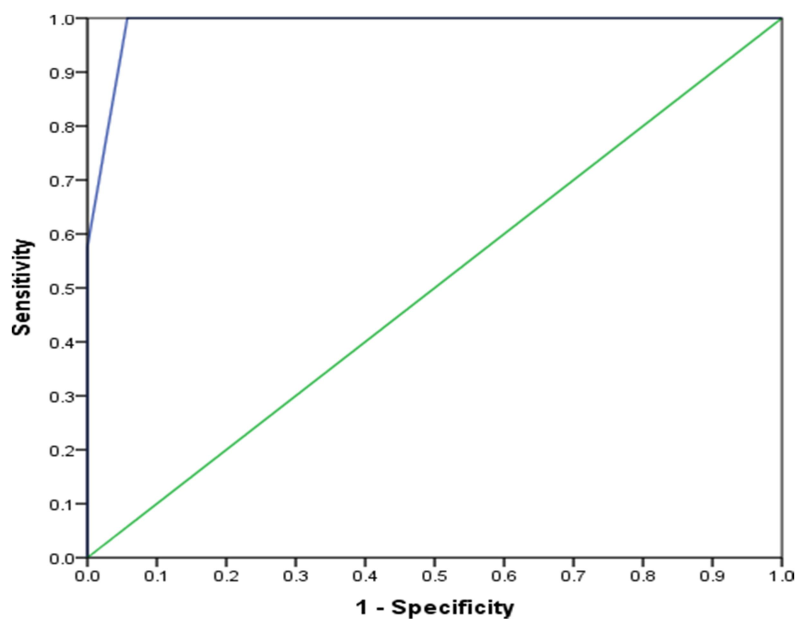

Figure 3. Receiver-Operator Characteristic (ROC) Curve of AC:SP Ratio for Prediction of Severity of Adenoid Hypertrophy (AH)

	Cut-off Value	Sensitivity (%)	Specificity (%)	Positive Predictive Value (PPV, %)	Negative Predictive Value (NPV, %)	95% Confidence Interval (CI)
AC:SP Ratio	0.66	67.58	57.43	65.52	58	0.472–0.674

The table presents the ROC curve analysis of the AC:SP ratio for predicting the severity of adenoid hypertrophy. Using a cut-off value of 0.66, the AC:SP ratio demonstrated 67.58% sensitivity, 57.43% specificity, 65.52% positive predictive value (PPV), and 58.0% negative predictive value (NPV), with a 95% confidence interval of 0.472–0.674.

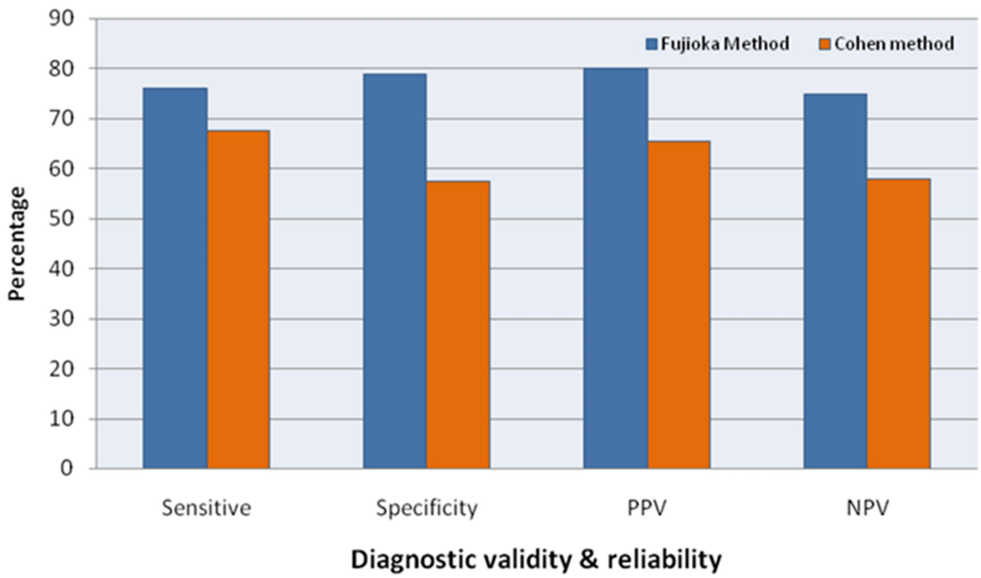

Figure 4. Comparison of Diagnostic Validity of Fujioka Method and Cohen Method (n = 50)

The figure illustrates the comparison of diagnostic validity and reliability between the Fujioka and Cohen methods for evaluating adenoid hypertrophy. The study demonstrated that the Fujioka method is a more reliable diagnostic tool and shows better consistency with clinical symptom grading compared to the Cohen method.

Discussion

This observational cross-sectional study was conducted at Chittagong Medical College Hospital, Chattogram, within its Department of Otolaryngology and Head & Neck Surgery. The objective was to determine the correlation between clinical evaluation and radiographic grading of adenoid hypertrophy (AH) in pediatric patients. A series of 50 consecutive children diagnosed with AH were selected according to specific inclusion and exclusion criteria. The cohort's mean age was 5.94 years (±0.72 SD), with over half (54.0%) falling into the 3–5-year age group. The sample comprised 39 males (78.0%) and 11 females (22.0%), yielding a male-to-female ratio of 3.5:1. Geographically, 70.0% of participants were from urban settings, while 30.0% were from rural areas.

These findings are consistent with previous studies. A cross-sectional study among 1,289 children aged 1–18 years in Bangladesh reported that 118 had evidence of enlarged adenoids on lateral nasopharyngeal X-ray, giving a prevalence of 2.3%. The peak age of diagnosis of AH in that study was 12–72 months (43.4%), with a mean age of 100.6 ± 58 months. Male participants were predominant, with a male-to-female ratio of 1.6:1. The most common clinical presentations were mouth breathing and nasal obstruction. AH may present without symptoms in 5% of cases or with complications such as obstructive sleep apnea

(OSA, 27%), adenoid facies (14%), and otitis media with effusion with or without hearing impairment (13%).[10]

In another study involving 201 children, the mean and median age was 4 years, with ages ranging from 1 to 7 years. Most children, 126 (62.7%), were aged 3–4 years, followed by 42 (20.9%) in the 5–7 years age group. The majority were male (117, 58.2%), and 140 children (69.7%) had adenoid hypertrophy.[13]

The present study demonstrated that mouth breathing/dyspnoea, snoring, and apnoea were the most common clinical presentations. Apnoea was noted in 38 (76.0%) children. Most patients had Grade 2 mouth breathing/dyspnoea and snoring, accounting for 62.0% and 58.0%, respectively. Overall, mild cases constituted 4 (8.0%), moderate cases 33 (66.0%), and severe cases 13 (26.0%). This finding aligns with a study from Saudi Arabia, where snoring was the most common complaint, followed by mouth breathing, adenoid facies, and sleep apnea.[22] Similarly, a study in India reported that mouth breathing and snoring were the most frequently observed clinical presentations.[23]

Clinical assessment remains the first-line evaluation tool for adenoid hypertrophy. However, limitations include difficulties in standardizing grading systems, which may affect preoperative evaluation.[24] Lateral radiographs of the soft tissue neck are inexpensive, widely available, reproducible, and comfortable for children, providing a simple method to determine the size, shape, and position of adenoids.[11] Some studies comparing radiographic assessment with nasoendoscopy concluded that radiography serves as a better planning tool.[12]

In this study, radiological assessment using the Fujioka method showed that ANR between 25 and 75% was found in 16 (32.0%) patients. Based on the ANR ratio, patients were categorized into three groups: mild AH (10%), moderate AH (58%), and severe AH (32%). Correlation with clinical scoring showed that 4 (80.0%) patients with mild AH correlated with clinical grading, 28 (96.5%) with moderate AH, and 12 (75.0%) with severe AH. The result was statistically significant ($P < 0.05$). Among various lateral neck radiograph interpretation methods, Fujioka (Fujioka et al.[17]) and Cohen (Cohen et al.[18]) methods are widely used and reliable.

A study from Saudi Arabia analyzing lateral soft tissue neck X-rays demonstrated a good correlation between radiographic adenoid size and clinical symptoms, supporting X-ray as a helpful diagnostic tool.[25]

In this study, radiological findings using the Cohen method showed AC:SP ratios >0.81 to ≤1 in 7 (14.0%) patients, >0.5 to ≤0.8 in 31 (62.0%), and ≤0.5 in 12 (24.0%). Based on AC:SP ratios, patients were categorized into mild AH (14%), moderate AH (62%), and severe AH (24%). Correlation with clinical scoring showed that 4 (57.1%) patients with mild AH, 26 (83.8%) with moderate AH, and 7 (58.4%) with severe AH correlated with clinical scoring, with statistical significance ($P < 0.05$).

These findings partially correspond with Yueniwati et al.[26], who reported that for the Cohen method, sensitivity was 94.7%, specificity 100%, PPV 100%, NPV 83.3%, and accuracy 95.8%. For the Fujioka method, sensitivity was 10.5%, specificity 100%, PPV 100%, NPV 22.7%, and accuracy 29.1%.

Jyothirmai et al.[23], also reported mouth breathing and snoring as the most common presentations of AH (98%), consistent with our study. Clinical symptom grading showed 60% of cases as Grade III, while lateral neck X-rays showed 51% as Grade III, demonstrating a significant correlation (P =

0.04). Dixit et al.[27], similarly reported that snoring was the most frequent symptom and correlated linearly with adenoid size, showing good agreement between symptoms and X-ray findings, consistent with the present study.
Receiver-operator characteristic (ROC) curve analysis in this study showed that the ANR ratio had a cut-off value of 0.61, with 76.19% sensitivity, 78.95% specificity, 80.0% PPV, and 75.0% NPV for predicting severity of AH. ROC analysis of AC:SP ratio gave a cut-off value of 0.66, with 67.58% sensitivity, 57.43% specificity, 65.52% PPV, and 58.0% NPV. The study demonstrated that the Fujioka method is a more reliable diagnostic tool for evaluating adenoid hypertrophy and correlates well with clinical symptom grading.

Adedeji et al.[24], conducted a study including 90 children (61 males, 29 females; M:F = 2.1:1), aged 8 months to 11 years. All patients presented with nasal obstruction, mouth breathing, and noisy breathing. The majority (64.5%) had severe obstruction, most commonly among children aged 3–5 years (39.9%). A strong correlation was found between clinical symptoms and nasopharyngeal airway obstruction determined by ANR. Moideen et al.[28], also reported that ANR is a reliable and valid diagnostic test with a significant correlation between symptom score and ANR, showing an overall diagnostic accuracy of 87.5%.

A study in Nairobi, Kenya, demonstrated two simple, reproducible radiological assessment methods—Fujioka and Cohen—with Fujioka showing better accuracy in classifying moderate and severe AH.[29] Another study reported that lateral nasopharyngeal X-ray had a sensitivity of 79.41%, specificity of 75%, and was effective in evaluating adenoid size in patients with hypertrophy.[30] These findings are consistent with the present study.

Limitations of the study

This study had certain limitations, which are as follows:

- It was a single-center study, including only patients admitted to CMCH. A larger, multi-center study is needed to reach more definitive conclusions.
- The sample size was relatively small.

Conclusion

Adenoid Hypertrophy (AH) is one of the most common clinical conditions in the pediatric age group seeking medical attention. However, assessing the size of the adenoids or nasopharyngeal tonsils, is challenging due to their anatomical location. The present study demonstrated that lateral radiographs of the nasopharynx are sensitive in evaluating children suspected of having AH in accordance with their clinical symptoms. Lateral nasopharyngeal radiography is inexpensive, readily available, reproducible, and comfortable for children, providing a simple method to determine adenoid size, shape, and position. The Fujioka method showed greater accuracy than the Cohen method in terms of diagnostic validity and reliability.

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