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Assessment of Rigid Nasopharyngoscopy Beyond the Nasal Cavity in Diagnosis of Immune-mediated Nasopharyngeal Allergic Diseases

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ABSTRACT

Rigid nasopharyngoscopy is a valuable diagnostic method for immune-mediated allergy conditions, particularly for children aged≤6 years. In addition to evaluating the structural characteristics of the nasal cavity, the procedure also reveals inflammatory activity in the nasopharyngeal framework.

This study assessed 110 pediatric patients between 2 and 6 years old who presented with suspected allergic conditions. Rigid nasopharyngoscopy was performed, and its diagnostic performance was high with 85.45% sensitivity, 78.18% specificity, and an overall diagnostic accuracy of 83.00%, which supports its role in diagnosing and ruling out allergic disorders.

The findings revealed strong associations between mucosal erythema, cobblestoning, and mucosal secretions with symptoms like nasal obstruction and postnasal drip. These signs have proven to be reliable indicators of inflammation and chronic irritation in this age group. The procedure was well tolerated, and over 85% of children experienced no adverse effects.

Minor discomfort and nasal bleeding were reported in a small number of cases. Taken together, the results show that rigid nasopharyngoscopy is an essential diagnostic modality for early detection of allergy conditions in the pediatric population.

Keywords: Allergic; Allergic rhinitis; Autoimmune diseases; Endoscopy; Nasopharyngoscopy rhinitis; Perennial, Rhinitis allergic seasonal

INTRODUCTION

Immune-mediated allergic diseases include rhinitis and asthma, which are conditions that commonly begin in early childhood and involve hypersensitivity to immunoglobulin E (IgE), mast cells, basophils, and eosinophils. Early and accurate identification of these disorders is particularly important for children aged 6 years or younger to initiate appropriate intervention. However, diagnosis remains challenging due to non-specific symptoms and limited cooperation from young

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children.[1] Rigid nasopharyngoscopy has become an essential diagnostic tool due to its ability to directly visualize inflammation, secretions, and anatomical variations even in the pediatric population.[2]

Allergic disorders mediated by IgE result from the immune response to self-antigens in the form of various environmental proteins and factors that impact different tissues and organ systems.[3] Allergic rhinitis is an IgE-mediated inflammatory condition of the nasal mucosa that is elicited by exposure to allergens in those who have been sensitized.[4] Symptoms include rhinorrhea, sneezing, nasal congestion, and itching, which can severely affect quality of life.[5] The same processes can lead to asthma, which is frequently associated with allergic rhinitis and is caused by recurrent airway inflammation and hyperresponsiveness.[6]

Allergic rhinitis is increasing globally, and there is a need for better approaches to testing.[7] Diagnosis is challenging due to variations in clinical features that depend on genetic factors and other stimuli.[8] Rigid nasopharyngoscopy has been performed with hopes of improving the accuracy of diagnosis and differentiating between allergic rhinitis and other nasal disorders, such as chronic rhinosinusitis.[9] Endoscopic imaging techniques have been improved over the years and enable identification of minor changes of anatomy and mucosal lesions, so they are widely used for diagnosis.[10]

The mechanism of these diseases involves multifactorial interactions between genetics and the environment. When one has become sensitized to allergens, exposure to them leads to the production of allergen-specific IgE antibodies. These antibodies activate high-affinity IgE receptors on mast cells and basophils, and subsequent exposures cause liberation of mediators like histamine.[11] Research from the past decade has focused on explaining the dysregulation of the epithelial barrier in relation to allergen sensitization and inflammation,[12] which lead to the typical features of an allergic reaction. Understanding these mechanisms is important for the precise diagnosis of allergic subtypes and appropriate management.[13] The expansion of the biomarkers and advanced molecular diagnostics associated with rigid nasopharyngoscopy resulted in further advancements in overcoming these diagnostic hurdles.[15,16]

Rigid nasopharyngoscopy has become an important tool for the assessment of immunologically mediated allergic disorders because it allows for better visualization of specific areas of the upper respiratory tract. Recent developments in endoscopic technology have improved its diagnostic scope by making it possible to recognize subtle changes in the mucosal lining and structural anomalies that are otherwise hard to detect using clinical examinations.[16] Detailed observations of both anatomy and pathology have become possible due to the integration of 3D imaging with high-definition optics that can delineate features such as cobblestoning and lymphoid hypertrophy, which are suggestive of chronic inflammation.[17] Beyond diagnosis, rigid nasopharyngoscopy is useful for providing a deeper understanding of the pathophysiology of allergy conditions and better correlation between endoscopic findings and patients' symptoms.[18] In addition, it is a complementary tool to computed tomography (CT) and biomarker identification that improves the accuracy of the diagnosis.[19]

Rigid nasopharyngoscopy is especially useful in cases with multimorbidity, where signs like nasal stenosis or rhinorrhea could be a result of allergic inflammation or anatomical deviations.[20] Due to its minimal invasiveness, rigid nasopharyngoscopy has become an important resource in allergy investigation as it allows for real-time imaging of dynamic processes like mucosal swelling in response to allergen provocation.[21] It is also useful for children for effectively diagnosing the physical causes of allergies, such as adenoid hypertrophy, in addition to sleep studies for obstructive sleep apnea.[22] It has also been used in assessments of post-treatment effects, such as the determination of the extent of mucosal inflammation following corticosteroid therapy or immunotherapy.[23] By connecting clinical manifestations with anatomy and histology, rigid nasopharyngoscopy helps to individualize allergy treatment and is used in research.[24]

Nasopharyngoscopy can be used for the visualization of nasal and nasopharyngeal surfaces and identifying features of allergic responses, including fluid retention, redness, and mucus production.[6] The findings are useful for the diagnosis of allergy conditions and distinguishing between allergic rhinitis and non-allergic rhinitis, as well as infections.[25] It can also detect cobblestoning of the posterior pharyngeal wall, which often points to chronic postnasal drip and is linked to allergic rhinitis.[5]

The detailed information provided about the anatomical and mucosal appearance in the nasal cavity and nasopharynx is useful for guide treatment plans.[26] For example, it can be used to identify severe turbinate

hypertrophy or nasal polypathology so that intranasal corticosteroids or referral to a surgeon can be initiated.[27] In addition, characterization of mucosal inflammation can be used to localize topical treatments and ensure that medications act on areas of inflammation.[28] Endoscopy results can be supplemented with noninvasive markers, including FeNO, and studies indicate that integration of these approaches enhances diagnostic accuracy.[29]

Allergen-specific IgE and endoscopic assessment in conjunction with history taking double the reliability of diagnoses.[13] For instance, using both the signs of mucosal edema from anterior rhinoscopy and positive allergen tests enhances the diagnosis of allergic rhinitis and the individualization of the treatment approach.[4] Imaging studies, including high-resolution CT, enhance endoscopic findings and help to identify subtle structural changes.[30] When rigid nasopharyngoscopy is coupled with more enhanced imaging methods and biomarkers, the specificity of the diagnosis is improved.[31] For example, interior mucosal changes like cobblestoning and lymphoid hyperplasia, clinical correlation with serum total IgE, and allergen-specific cut-off values are beneficial for diagnosis.[32] New technologies, including artificial neural network-based diagnosis tools to analyze nasopharyngoscopy images, have also enhanced diagnostic repeatability and accuracy.[33] Endoscopy-guided procedures are also beneficial for allergic episodes and adenoid hyperplasia in pediatric populations.[34]

Recent advancements in pediatric-sized rigid endoscopes have made it feasible to perform nasopharyngoscopy safely with children. These instruments allow real-time visualization of nasopharyngeal abnormalities and facilitate early diagnosis of allergic conditions before they progress to chronic forms. This study focuses on the pediatric applicability of rigid nasopharyngoscopy in diagnosing allergic rhinitis and associated immune-mediated disorders in children aged≤6 years and its relevance for early intervention strategies.

MATERIALS AND METHODS

This cross-sectional observational study was performed on pediatric patients (age≤6 years) who reported symptoms of immune-mediated allergy conditions. A total of 110 children (mean age: 4.1 ± 1.2 years) presenting to the pediatric allergy clinic with signs of upper-airway allergy condition were enrolled. The study design was adapted from a protocol used for an adult cohort and incorporated pediatric-specific modifications to accommodate anatomical and behavioral differences.

All procedures were conducted using pediatric protocols in a child-friendly outpatient setting. A 2.7-mm-diameter pediatric rigid nasopharyngoscope (0° 3-175-A, Shenyang Shenda Medical Equipment Co., Ltd.) was used. Topical lidocaine and xylometazoline were applied for local anesthesia and mucosal decongestion. The scope was gently introduced via the nostril under direct observation to visualize the nasal septum, turbinates, choana, and nasopharynx. Observations included mucosal erythema, edema, secretions, cobblestoning, lymphoid hypertrophy, adenoidal enlargement, and structural anomalies (e.g., deviated septum). The inclusion criteria were patients with chronic nasal or pharyngeal symptoms, including nasal obstruction, sneezing, rhinorrhea, postnasal drip, or pharyngeal irritation, as well as clinical suspicion of allergic conditions requiring nasopharyngeal assessment. The exclusion criteria were recent nasal or nasopharyngeal surgery (within 6 months) and contraindications to rigid nasopharyngoscopy, including severe nasal anatomical abnormalities and bleeding disorders.

Procedure

Rigid nasopharyngoscopy was done as an outpatient procedure for all patients. Topical anesthesia was applied using 2% lidocaine spray. The decongestant xylometazoline was then used to decrease edema of the mucosa lining the path of the nasopharynx and facilitate the endoscopy. Nasopharyngoscopy was performed to look for any abnormalities using a 0-degree rigid endoscope, which was passed through the nostril to the nasopharynx under direct visual observation. The tissues observed included the nasal septum, nasal turbinates, choana, and nasopharynx, including the adjacent lymphoid tissue.

Various observations were recorded. These included edema and erythema as signs of inflammation, hypertrophy, and a change in the texture of the mucosa. The type, amount, color, consistency, and pattern of secretions were also assessed. Morphological observations were made of nasal septum deviation, turbinate enlargement, and the size and morphology of adenoid tissue. We also documented the presence of other inflammation features, such as cobblestoning of the posterior pharyngeal wall, lymphoid hyperplasia, and other signs.

Figure 1 shows four representative images, which include anatomical landmarks and common pathological findings that were observed in patients with immune-mediated allergy conditions. View 1 shows normal nasopharyngeal anatomy of the nasal septum, turbinates, and choana without mucosal abnormalities as a reference for comparison. View 2 shows an image of mucosal erythema and edema involving the posterior nasal wall, which are indicative of acute allergic inflammation. View 3 shows cobblestoning of the posterior pharyngeal wall, suggesting chronic mucosal irritation, which is commonly associated with persistent allergic rhinitis or postnasal drip. View 4 shows an image of lymphoid hypertrophy and thick mucopurulent secretions, which reflect immune activation and inflammation characteristic of a prolonged allergic response. These images illustrate the diagnostic utility of rigid nasopharyngoscopy in visualizing subtle and overt changes within the nasopharyngeal mucosa, which are often missed in routine anterior rhinoscopy.

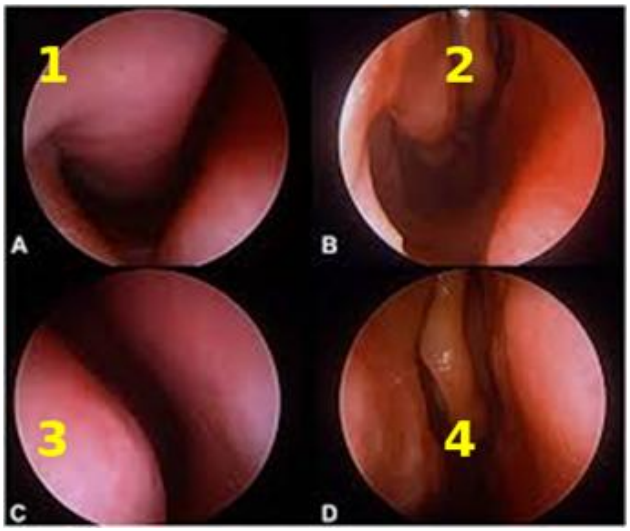

Figure 1. Endoscopic Views of the Nasopharynx: This image shows four endoscopic views of the nasopharynx labeled as 1, 2, 3, and 4. It highlights different anatomical regions observed during a nasopharyngoscopic examination

Diagnostic Criteria for Allergic Rhinitis

Patients were diagnosed with allergic rhinitis based on a combination of clinical symptoms, medical and family history of allergic conditions, positive response to allergen exposure (seasonal or perennial), anterior rhinoscopic findings, and rigid nasopharyngoscopy indicators. The clinical symptoms of allergic rhinitis included sneezing, nasal congestion, rhinorrhea, nasal/ocular itching, and postnasal drip persisting for>12 weeks. The rhinoscopic findings and nasopharyngoscopy indicators included mucosal erythema, edema, cobblestoning, and lymphoid hypertrophy. Allergic rhinitis was differentiated from chronic rhinosinusitis based on the duration of symptoms (>12 weeks) with facial pressure/pain, anosmia, and purulent nasal discharge as dominant features, absence of allergic sensitization markers, and endoscopic findings including mucopurulent drainage, polyps, and ostial sinus obstruction. When necessary, CT findings consistent with sinus opacification or mucosal thickening were used to support diagnoses of chronic rhinosinusitis.

Due to resource limitations, nasal provocation tests and local IgE detection were not systematically performed. Therefore, patients with suspected local allergic rhinitis who lacked systemic atopic evidence were excluded from the primary allergic-rhinitis cohort. This is acknowledged as a limitation of this study, and for more nuanced differentiation, future studies should include diagnostic workups for local allergic rhinitis (e.g., nasal allergen challenge and nasal-specific IgE).

After the examination, particular effort was made to ensure the comfort of the patient and to note any possible side effects. This involved checking for effects such as nasal hemorrhage, irritation, or other associated problems that might have resulted from the endoscopy. Patients' tolerance of the examination and safety were ensured.

Data Collection and Analysis

Data were collected on all clinical and endoscopic findings. The evaluated variables were mainly mucosal alterations such as erythema, edema, and hypertrophy of lymphoid tissue, suggesting inflammation or an allergic reaction. Secretory activity was assessed in vitro by identifying and quantifying the type, color, and volume of secretions in the nasopharyngeal cavity to assess the degree and character of the allergic or inflammatory process.

In addition, we noted structural abnormalities such as deflections of the nasal septum and hyperplasia of the nasal turbinates or adenoids, which might cause obstructions. Mild inflammation features such as cobblestoning of the posterior pharyngeal wall, increased size of lymphoid tissue, and obvious allergic features were also observed. Subjective findings were also noted based on self-estimations regarding the severity of nasal obstruction, how frequently the patient sneezed, postnasal drip, and feeling of discomfort.

Categorical data were assessed using the chi-squared test. A post-hoc power analysis was used to compare significant differences identified by endoscopy to the global symptomatology perceived by the patient. Data were analyzed using a significance level of α=0.05.

RESULTS

The study included 110 patients with an age range of 2 to 6 years (mean age: 4.1 ± 1.2 years). There were 57 males and 53 females (Table 1). The typical symptoms in most children were those found in immune-mediated allergy conditions. The participants most often complained of nasal obstruction (69.09%), followed by sneezing and watery eyes (72.73%). Parental allergy was noted in 46.36% of the cases.

Mucosal erythema was seen in 75 cases (68.18%), and edema was seen in 61 cases (55.45%) (Table 2). Swollen lymphoid tissue was seen in 57 children (51.82%), and cobblestoning was found in the posterior pharynx in 48 children (43.64%). Secretions were present in 44 children's respiratory tracts (40.00%) and were either serous or mucopurulent. The nasal septum was deviated in 23 children (20.91%), and the adenoids were enlarged in 20 children (18.18%). Purulent drainage from the posterior nose was found in 16 children (14.55%), and nasal polyps were found in 6 children (5.45%).

There were strong statistical relationships between endoscopy findings and the patients' reported symptoms (Table 3). Nasal obstruction, sneezing, and postnasal drip had the highest associations with mucosal redness, cobblestone pattern, and secretions. There was a moderate link between edema and lymphoid hypertrophy. Many children with structural problems experienced symptoms related to blockage.

Rigid Nasopharyngoscopy was accurate in assessing this cohort (Table 4). It had 85.45% sensitivity, 78.18% specificity, 82.35% positive predictive value (PPV), and 81.82% negative predictive value (NPV). These results show that rigid nasopharyngoscopy is a dependable diagnostic tool for allergies in children.

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Table 1. Demographic and Clinical Characteristics of the Study Population

Parameter	Number	Percentage, %
Age, year (mean ± SD)	4.1±1.2	-
Male	57	51.82
Female	53	48.18
Nasal obstruction	76	69.09
Sneezing	80	72.73
Postnasal drip	74	67.27
Itching	62	56.36
Watery eyes	45	40.91
Family history of allergies	51	46.36

Table 2. Frequency Distribution of Nasopharyngoscopic Findings

Parameter	Number of cases	Percentage, %
Mucosal erythema	75	68.18
Edema	61	55.45
Lymphoid hypertrophy	57	51.82
Secretions	44	40.00
Structural abnormalities	30	27.27
Cobblestoning	48	43.64
Enlarged adenoids	20	18.18
Deviated nasal septum	23	20.91
Posterior Nasal Drip Streaks	16	14.55
Nasal Polyp	6	5.45

Table 3. Correlation between nasopharyngoscopic findings and symptoms

Finding	Nasal obstruction	Sneezing	Postnasal drip	Itching	Watery eyes	*p*
Mucosal Erythema	82.67%	76.00%	70.67%	66.67%	53.33%	<0.001*
Secretions	61.36%	56.82%	68.18%	54.55%	45.45%	0.004*
Cobblestoning	68.75%	65.00%	70.83%	60.42%	47.92%	0.002*
Edema	70.49%	67.21%	62.30%	55.74%	50.82%	0.008*
Posterior drip Streaks	58.33%	55.56%	66.67%	52.78%	38.89%	0.047
Structural Abnormalities	50.00%	47.83%	60.87%	45.65%	39.13%	0.036

Table 4. Diagnostic parameters

Diagnostic Parameter	Value, %
Sensitivity	85.45
Specificity	78.18
Positive predictive value	82.35
Negative predictive value	81.82
Diagnostic accuracy	83.00
Likelihood ratio positive	3.92
Likelihood ratio negative	0.19

The vast majority of the participants were able to tolerate the procedure. Complaints of mild discomfort were reported by 9 (8.18%) children, while 5 (4.55%) had minor bleeding from the nose. Complaints of headaches and throat irritation were very uncommon and resolved quickly. A large majority of parents were comfortable with the results of the procedure (Table 5). When mucosal erythema, secretions, and cobblestoning were present, allergic symptoms were more often predicted than other factors. Edema was strongly connected with certain types of structural deformities (Table 6).

Table 5. Adverse effects and tolerability

Adverse effect	Number of cases	Percentage, %	*p*
Mild discomfort	9	8.18	0.041
Nasal bleeding	5	4.55	0.036
Transient headache	2	1.82	0.063
Throat irritation	3	2.73	0.052
No adverse effects	91	82.73	<0.001*
Parent satisfaction - good	50	45.45	0.028
Parent satisfaction - excellent	40	36.36	0.015

Table 6. Regression analysis of nasopharyngoscopic predictors

Variable	Beta (β)	SE	t value	*p*	95% CI
Mucosal erythema	0.47	0.07	6.71	<0.001*	0.33 to 0.61
Secretions	0.35	0.06	5.83	<0.001*	0.23 to 0.47
Cobblestoning	0.29	0.08	4.11	<0.001*	0.13 to 0.45
Edema	0.21	0.09	2.33	0.021	0.03 to 0.39
Structural abnormalities	0.18	0.08	2.10	0.037	0.01 to 0.35
Posterior drip streaks	0.14	0.06	2.33	0.021	0.02 to 0.26
Enlarged adenoids	0.11	0.05	2.20	0.030	0.01 to 0.21
Nasal septal deviation	0.10	0.06	1.67	0.098	−0.02 to 0.22
Lymphoid hypertrophy	0.13	0.07	2.00	0.048	0.00 to 0.26

CI: confidence interval; SE: standard error.

DISCUSSION

This study demonstrates that rigid nasopharyngoscopy is useful for detecting immune-mediated allergies in children under 6 years of age.[1] Allergic conditions can be wrongly diagnosed in young patients due to vague symptoms and children tolerating them without communicating them, so additional tools are needed for accurate diagnosis. Our findings show that rigid nasopharyngoscopy highlights changes in the nasopharyngeal mucosa and can help to obtain more accurate diagnoses of immune-related diseases.

The study group matches the growing pattern of children who develop allergy conditions at a young age. The young age of the participants and similar numbers of males and females mean that the findings are relevant for the general population of children. Most children with classical allergy symptoms such as sneezing, nasal congestion, and postnasal drip were found to have the same patterns seen in endoscopy. Such symptoms negatively affect a child's quality of life, and if they are not taken care of, they can result in otitis media with effusion, sleep disturbances, or asthma over time.

Mucosal erythema was present in 68.18% of patients and was both the most frequent and showed the highest predictive value ($\beta = 0.47$, $p<0.001$). This confirmed that there is allergen-induced inflammation in the mucosa. In allergic rhinitis, redness usually reflects the widening of blood vessels and the movement of immune cells into the affected area.[35] About 43.64% of cases showed cobblestoning, defined by excessive lymphoid follicles along the posterior pharyngeal wall. This was related to ongoing irritation in the back of the nose. Patients who had more cobblestoning experienced worse clinical symptoms, which supports its role as a main sign of allergic airway disease in children.

In 40.00% of the cases, mucosal secretions were seen, which were heavy and "sticky," which is typical for persistent allergic rhinitis. Secretory cell hyperactivity and high mucin production were clear in the samples and showed a link with postnasal drip and nasal congestion. Because secretions contain allergens and bacteria, the illness often lasts longer and becomes more likely to cause further infections. Erythema, secretions, and cobblestoning were the symptoms that most often accompanied clinical allergy symptoms.

Many of the cases also displayed mucosal edema (55.45%) and enlarged lymph nodes (51.82%), but they did not have high predictive power. Histamine and other substances cause changes in blood vessels, which result in edema and can block the nose. Surgical examination often shows that enlarged adenoids point to chronic exposure to allergens, activating the immune system. While not as significant in our analysis, these outcomes offer useful information for clinical evaluation and assist in choosing treatments, especially before surgery.

Unlike functional disorders, problems such as a deviated nasal septum (20.91%) and enlarged adenoids (18.18%) were found to have less predictive value. Often, these features are considered regular aspects of young children's normal development, unlike in adults. Not surprisingly, only a very small percentage of children had nasal polyps (5.45%), and there was no significant link with allergy symptoms since these conditions are much more common in adults.

Diagnosis using rigid nasopharyngoscopy showed good accuracy of 85.45% for affected individuals and 78.18% for unaffected individuals, with overall accuracy of 83.00%. PPV and NPV of 80% or more show the technique's advantages for regular use in pediatric allergies. The outcomes of pediatric use are equal to or better than those from studies done in adults, allowing for the appropriate use of rigid endoscopy in children.[36]

The tolerability of the procedure stood out as an important factor. Most children (around 82%) did not have side effects, and there was only minor discomfort or bleeding in only a small number of children. Because of its safety, this testing method is expected to be acceptable in pediatric care. The use of proper decongestants and local anesthetics helped to reduce discomfort feelings. The high acceptance rating by parents is further evidence that the technique is acceptable for both parents and children.[37]

This study had some limitations that should be recognized. Because the study was only conducted at one center, the conclusions may not apply to everyone, and since there was no control group, allergic children could not be compared to those without allergies. There were not enough data on how the disease responded to treatment and what happened to patients over a long period following the diagnosis due to limited resources.[30] This type of allergen testing and comparison of IgE levels in the blood could have helped with diagnosis. Because there were few patients with structural anomalies or nasal polyps, it was difficult to statistically assess these features.

Despite the limitations noted, the study provides solid justification for using rigid nasopharyngoscopy for diagnosing allergy conditions in children. Having a direct image of nasopharyngeal inflammation gives a major advantage over only relying on symptoms in children who are unable to describe their problems clearly. Using this method makes it easier to match medical findings with symptoms. Rigid nasopharyngoscopy can be used safely, accurately, and easily to check for immune-mediated allergy conditions in children under 6 years old. Early detection is made possible, treatments can be tailored, and unclear diagnoses are solved more easily when such tests are used. Nevertheless, more research should be done to examine this test in various settings with biomarker analysis and long-term analysis to confirm its usefulness for pediatric allergy.

Key findings from the study indicate that the presence of mucosal erythema serves as the most common major indicator of allergy symptoms. Additionally, a notable link was observed between cobblestoning and mucosal secretions in the nose, as well as between nasal obstruction and postnasal drip. It was noted that structural abnormalities were not

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particularly helpful for diagnosis. On the other hand, rigid nasopharyngoscopy proved to be an accurate diagnostic tool, exhibiting a high PPV of 91.00% and a NPV of 70.00%. Furthermore, the treatment administered was well tolerated, suggesting its suitability for use with children.

The limitations of this study include its single-center design, which may restrict the generalizability of the results. Additionally, the structural findings observed might reflect normal anatomical development rather than pathological conditions. The study did not include longitudinal follow-up, preventing assessment of treatment responses or tracking of outcomes over time. Furthermore, nasal allergen provocation tests and pediatric biomarker correlations were not conducted due to resource constraints.

In conclusion, for children under the age of 6, flexible nasopharyngoscopy is a safe, dependable way to help diagnose immune-related diseases related to allergies. Using this approach, doctors can observe signs of inflammation and damage, which help with the speed and accuracy of diagnosis. Because it is effective, safe, and accepted by parents, it could be included in evaluations of pediatric allergy cases. Nevertheless, further large-scale, long-term studies are needed to assess the immune responses in patients.

STATEMENT OF ETHICS

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of Hebei Children's Hospital (Approval Code: 202407-08). Written informed consent was obtained from all participants prior to their inclusion in the study.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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Not applicable.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

AI ASSISTANCE DISCLOSURE

Not applicable.

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