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PEDIATRIC ORL

Modified adenoid grading system for evaluating adenoid size in children: a prospective validation study

Haiyan Liu[1] · Xiaoshan Feng[1] · Yueqi Sun[1] · Yunping Fan[1] · Jinxiu Zhang[1]

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Abstract

Nasal endoscopy is the best choice for evaluation of adenoid size, but very few studies published on the endoscopic quantitative assessment. This study aimed to newly propose and validate a modified adenoid grading system (MAGS) with the existing endoscopic scoring methods of adenoid size. A prospective study on children with chronic mouth breathing and having endoscopic nasal examination was conducted. Digital images obtained during endoscopic examination were evaluated with the traditional method and the MGAS. Adenoid size was also evaluated by intraoperative nasal endoscopy among those underwent adenoidectomy. One hundred and thirty patients were enrolled. The MAGS showed high inter-rater reliability with a Kappa score of 0.869. Sixty of 130 patients underwent adenoidectomy and assessed with intraoperative nasal endoscopy. The MAGS significantly correlated to the percentage of nasopharyngeal obstruction of intraoperative endoscopy (Spearman's $r = 0.796$, gamma coefficient = 0.94), and the percentage of choanal obstruction of preoperative endoscopy (Spearman's $r = 0.816$, gamma coefficient = 0.859). Our findings suggest that the MAGS has high reliability and validity for assessment of adenoid size. It may be a more suitable and reliable grading system for endoscopic evaluation of adenoid size.

Keywords Adenoid size · Adenoid hypertrophy · Nasal endoscopy · Endoscopic adenoid grading · Adenoidectomy

Introduction

Adenoid hypertrophy, the unusual growth of the adenoid tonsil, is one of the most common conditions in the pediatric population [1]. It is often associated with sleep snoring or apnea, nasal obstruction, recurrent otitis media, and craniofacial anomalies such as the adenoid facies [2–4]. Adenoidectomy, a surgical procedure in which the adenoids are partially removed, is one of the most commonly performed operations in children [5]. Over the past several decades, upper airway obstruction caused by adenoid hypertrophy has become the leading indication of adenoidectomy [5].

Evaluation of the adenoid size and the degree of obstruction it causes is the initiative for indication of adenoidectomy. Various methods have been proposed in literature for assessment of adenoid size, such as nasal endoscopy [6], rhinomanometry [7], acoustic rhinometry [8] and radiologic imaging modalities [9, 10]. Among these approaches, nasal endoscopy have been shown its superiority to other methods, such as classical mirror examination, physical palpation [11], and lateral radiographs [12, 13]. However, very few studies have been published on the endoscopic quantitative evaluation of adenoid size. Recently, Parikh et al. proposed an endoscopic grading system for assessment of adenoid size, which was based on anatomic relationship between adenoids and the adjacent structures vomer, torus tubaris and soft palate [14]. However, subsequent study showed its poor relationship with clinical symptoms and type of tympanometry [15]. The reason for this might be because of using wrong anatomical landmarks for the adenoid grading system [14, 15].

In the present study, we newly proposed a modified adenoid grading system (MAGS) modified upon the method of

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Haiyan Liu and Xiaoshan Feng contributed equally to this work.

✉ Yunping Fan
zhfyp8835@163.com

✉ Jinxiu Zhang
entzjx@163.com

[1] Department of Otolaryngology, The Seventh Affiliated Hospital, Sun Yat-Sen University, No.628, Zhenyuan Road, Guangming (New) District, Shenzhen 518107, Guangdong, China

Parikh et al. [14] for evaluation of adenoid size. To assess the inter-rater reliability and validity of this MAGS score, we examined agreement on MAGS score between raters, and whether MAGS score correlated closely with previously reported endoscopic nasopharyngeal scores.

Methods

Subjects and study design

The study was conducted in the institution (blinded as requested) between November 2019 and June 2020. Study protocol was approved by the Internal Ethics Committee of the institution (blinded as requested). All participants' parent provided informed consent after having the detailed information about the study. All aspects of the study were conducted according to the Declaration of Helsinki.

Children who had symptoms associated to chronic mouth breathing such as snoring, nasal obstruction and sleep apnea, and required nasal endoscopy were prospectively recruited in an outpatient setting. Those refused to undergo or unable to cooperate with the diagnostic nasal endoscopy were excluded. Among the included children who underwent adenoidectomy, intraoperative evaluation of adenoid size was performed under general anesthesia as described below.

Nasal endoscopic examination and preoperative evaluation of adenoid size

Nasal endoscopic examination was performed in the supine position by an experienced endoscopic technician (X.F). A mixture of tetracaine HCL 1% and oxymetazoline HCL 0.025% spray applied by a pressurized nozzle was used for nasal topical anesthesia prior to nasal endoscopic examination. Each spray contained 2 mg of tetracaine HCL and 0.05 mg of oxymetazoline HCL. For children weighing < 40 kg, 2 sprays were applied, while for those weighing ≥ 40 kg, 2 additional spray were applied with 5 min apart. Endoscopic images were recorded during endoscopic nasal examination using a 0-degree 2.7 mm rigid nasal endoscope (Richard Wolf, Tuttlingen, Germany). An otolaryngologist (H.L) took an image in which choana was totally visualized to calculate the obstruction ratio of adenoid tissue to choanal opening for each patient. At the meantime, images were evaluated and scored according to the MAGS by two independent otolaryngologists (H.L and Y.S) who were blinded to each other.

Modified adenoid grading system

The MAGS was developed based on the anatomic relationships between the adenoid tissue and the following four structures: salpingo-pharyngeal fold, vomer, salpingo-palatine fold and soft palate (Table 1), in which adenoid size can be categorized into five grades. Grade 0, adenoid tissue has no contact with either of the above four structures. Grade 1, adenoid tissue only has contact with salpingo-pharyngeal fold. Grade 2, adenoid tissue is in contact with both salpingo-pharyngeal fold and vomer. Grade 3, adenoid tissue is in contact with both salpingo-palatine fold and vomer. Grade 4, adenoid tissue is in contact with salpingo-palatine fold, vomer and soft palate (Fig. 1).

Intraoperative evaluation of adenoid size

Standard procedures were performed on each patient. General anesthesia and endotracheal intubation were performed by a pediatric anesthesiologist. An age and size appropriate Crowe–Davis mouth gag was placed and the soft palate was retracted with a flexible catheter. Two senior authors (J.Z and Y.S) who were blinded to the results of the preoperative endoscopic assessment completed the examination of nasopharynx. An assessment of the adenoid pad was made by introducing a 70-degree 4 mm rigid nasal endoscope (Richard Wolf, Tuttlingen, Germany) through mouth. As reported elsewhere [10, 16], the size of adenoid pad was determined based on the degree of nasopharynx obstruction from the superior to inferior boarder or the choana, eliminating the plate position from the equation. The result was recorded as a percentage and this value was used as the standard result of adenoid size in this study.

Statistical analysis

Statistical analyses were performed with SPSS version 22.0 statistical software (IBM SPSS, Armonk, NY). The Cohen's Kappa statistical analysis was used for inter-rater reliability of MAGS. Pearson correlation (if both methods were continuous variables), or Spearman correlation (for comparison of

Table 1 Modified adenoid staging system: anatomic relationship between the adenoid tissue and salpingo-pharyngeal fold, salpingo-palatine fold, vomer and soft palate

Grade	Anatomic structures in contact with adenoid tissue
0	None
1	Salpingo-pharyngeal fold
2	Salpingo-pharyngeal fold Vomer
3	Salpingo-palatine fold Vomer
4	Salpingo-palatine fold Vomer Soft palate

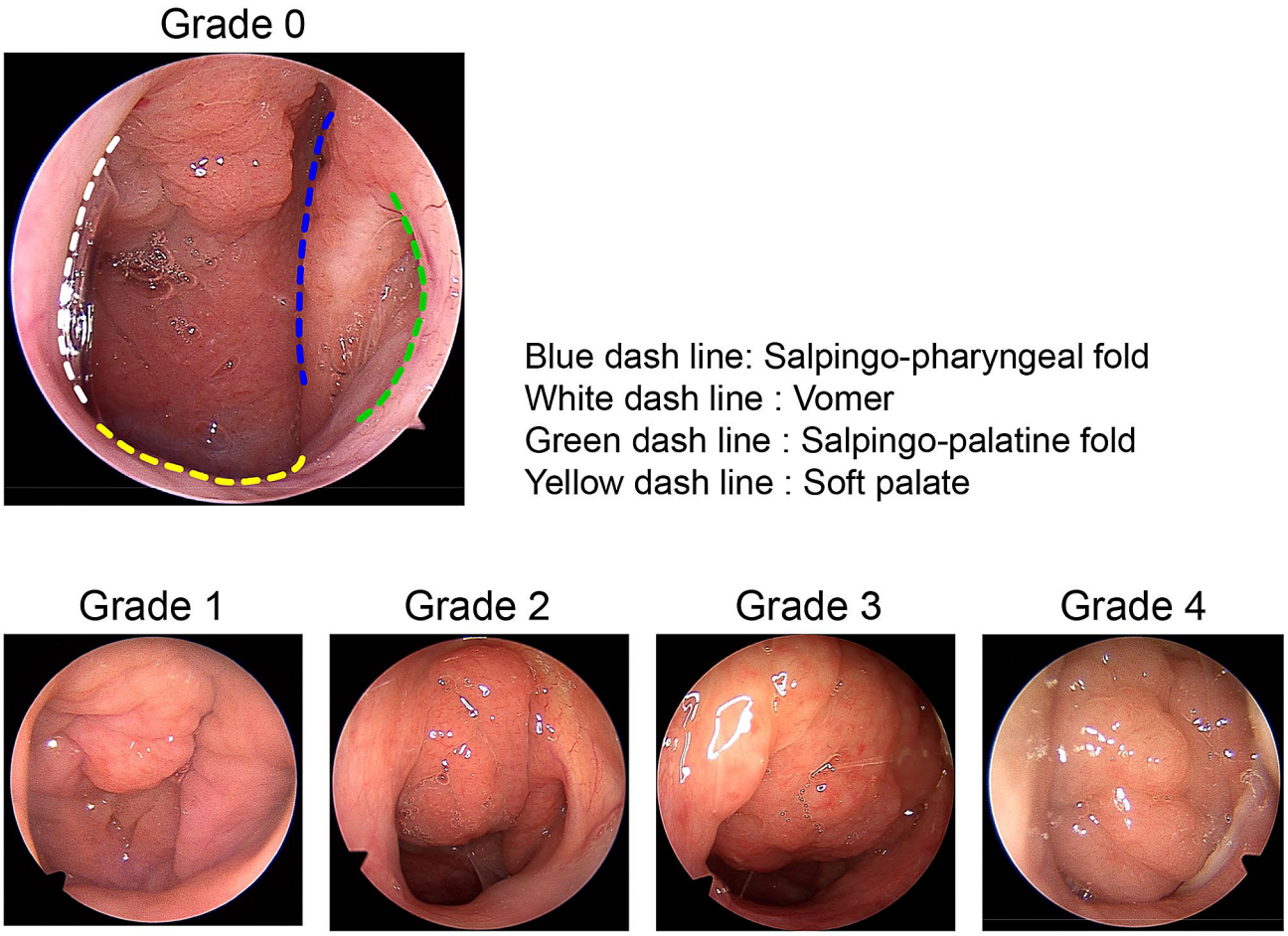

Fig. 1 Representative endoscopic view of adenoids using the MAGS

ordinal variables) was used for comparison of adenoid size assessment between different methods. The Gamma statistic, which is a correlation coefficient for ordinal data, was also used for the comparisons of the MAGS to the other methods. For this statistic, continuous variables were first converted from a 0–100% scale to a 0–4 scale. Linear regression was also used to determine the association of the percentage of nasopharyngeal obstruction of intraoperative endoscopy with the MAGS scores and the percentage of choanal obstruction of preoperative endoscopy, in which the slope of regression line was tested for statistical significance against a specific value of 1 defined as the slope of a line representing the best possible agreement between the two methods. A slope close to 1 indicates good agreement. A student *t* test was used to compare the slope to 1. A *P* value of less than 0.05 was considered statistically significant.

Results

A total of 130 patients, 77 males and 53 females, between the ages of 3 and 16 years (mean age, 6.3 ± 2.2 years) completed the diagnostic nasal endoscopy and were enrolled for inter-rater reliability analysis of MAGS. After excluding those did not need surgery treatment, 60 patients underwent adenoidectomy were included for criterion validity analysis of MAGS (Fig. 2).

With the Kappa measurement of agreement, an overall score of 0.869 was obtained, which is greater than 0.80, suggesting an "almost perfect" strength of agreement [14].

Correlation analysis between the MAGS scores and the percentage of choanal obstruction of preoperative endoscopy was then performed. The Spearman correlation

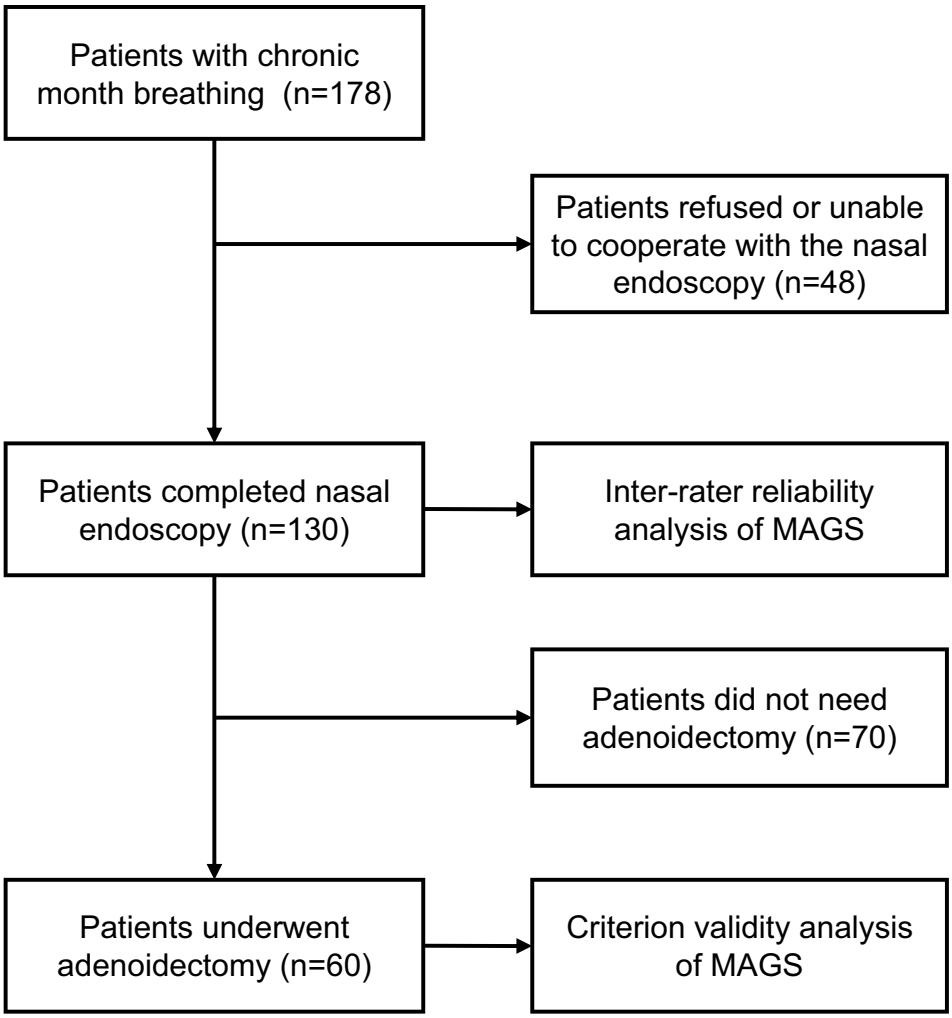

Fig. 2 Patient enrollment and study scheme

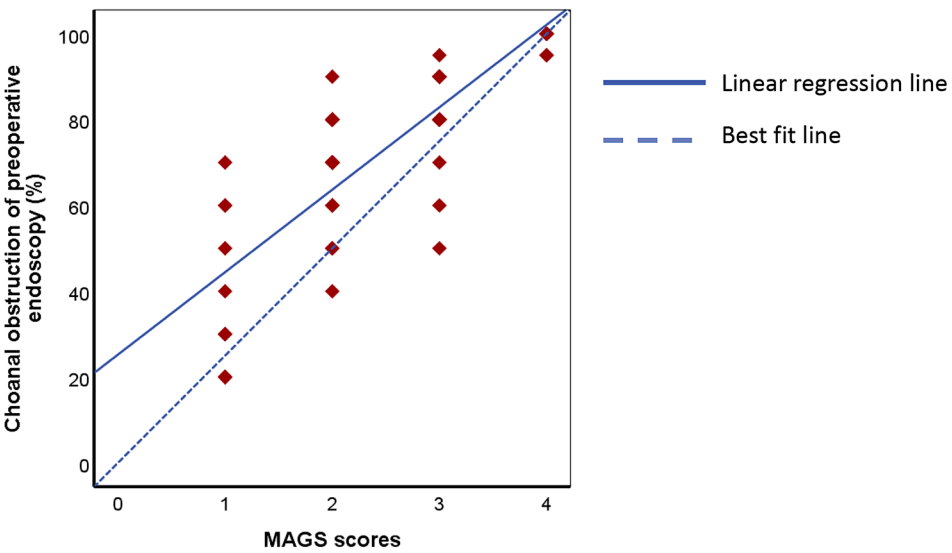

Fig. 3 Correlation between the choanal evaluation of preoperative endoscopy and the MAGS

coefficient was found to be 0.816 ($p < 0.0001$). The gamma coefficient was determined to be 0.859 ($p < 0.0001$) (Fig. 3). The median and range of the percentage of choanal obstruction of preoperative endoscopy in MAGS grade 1, 2, 3 and 4 were 25% (10–50%), 70% (40–90%), 80% (70–90%) and 90% (90–100%), respectively.

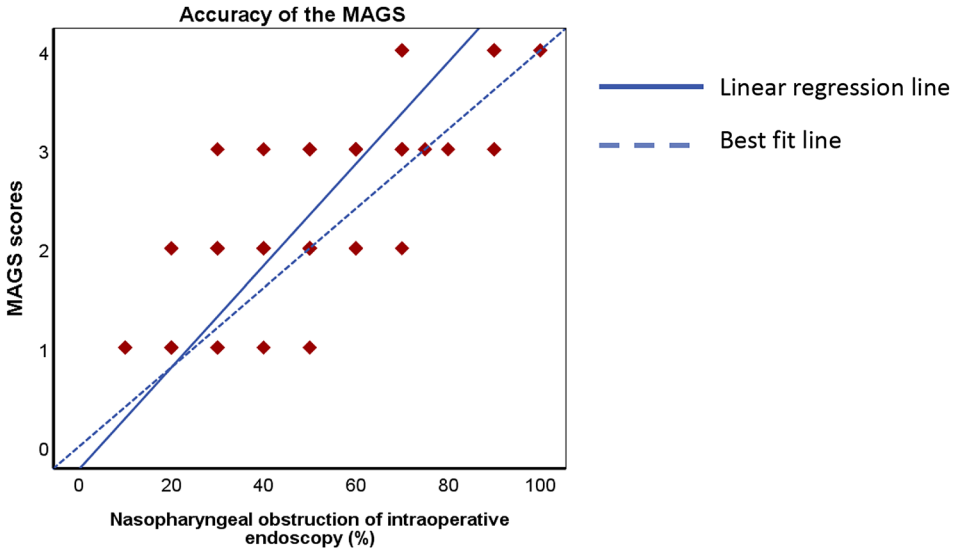

Fig. 4 Assessing the accuracy of the MAGS

The correlation analysis between the MAGS scores and the percentage of nasopharyngeal obstruction of intraoperative endoscopy demonstrated a Spearman correlation coefficient of 0.796 ($P < 0.0001$) (Fig. 4). When performed with age stratification, the Spearman correlation coefficient in children younger than 9 years and older than 10 years were 0.845 and 0.82, respectively, suggesting the variance in the measurement of MAGS is neglectable. The Goodman and Kruskal's gamma coefficient, representing the strength of the correlation coefficient, was determined to be 0.94 ($p < 0.0001$), indicating an excellent correlation between the two methods (Fig. 4). In addition, the slope of the regression line, which represented the MAGS, is 0.801 ($p < 0.0001$). The test for accuracy showed that the trend line of the MAGS had no significant difference from the best fit line ($P = 0.38$), suggesting the MAGS has the best agreement with the nasopharyngeal assessment of intraoperative endoscopy. The median and range of the percentage of choanal obstruction of intraoperative endoscopy in MAGS grade 1, 2, 3 and 4 were 20% (10–50%), 50% (20–70%), 60% (50–90%) and 90% (70–100%), respectively.

The correlation analysis between the percentage of choanal obstruction of preoperative endoscopy and the percentage of nasopharyngeal obstruction of intraoperative endoscopy demonstrated a Pearson correlation coefficient of 0.671 ($p < 0.0001$), showing a significant amount of correlation (Fig. 5). However, the slope of the regression line, which represented the degree of choanal obstruction of preoperative endoscopy, is 0.679 ($p < 0.0001$), and the test for accuracy revealed that the choanal obstruction measure generated from preoperative endoscopy varied significantly from the best fit line ($p = 0.027$), suggesting that the two methods

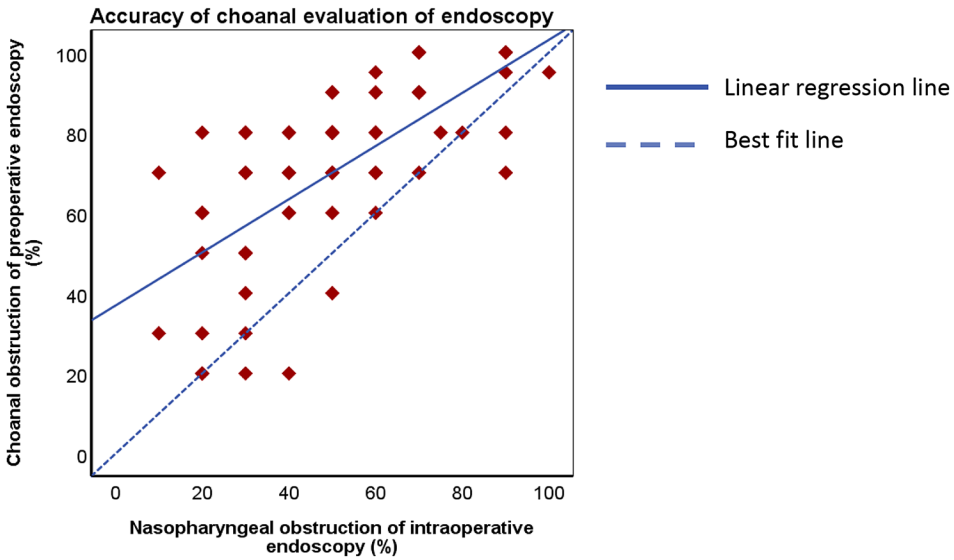

Fig. 5 Assessing the accuracy of choanal evaluation of preoperative endoscopy

were not in agreement. Overall, preoperative endoscopy appeared to overestimate the degree of adenoid size (Fig. 5).

Discussion

Quantification of adenoid size is important for providing information for clinicians in indicating adenoidectomy and directing ongoing treatment in children with chronic month breathing. With providing a direct view of the adenoid, while little discomfort to the patient, endoscopic nasal examination has become the best initial choice for evaluation of adenoid size. However, although endoscopic scoring methods exist [14], they have not been validated or did not adequately reflect the clinical symptoms [15], thus new endoscopy scoring systems are still being sought. In the present study, we newly proposed and validated the MAGS based on anatomic relationship between adenoids and the four adjacent structures salpingo-pharyngeal fold, vomer, salpingo-palatine fold and soft palate (Fig. 1 and Table 1) with a prospect cohort. We found that the MAGS had high inter-rater reliability with a Kappa score of 0.869. Among the patients who underwent adenoidectomy, the MAGS significantly correlated to the percentage of nasopharyngeal obstruction of intraoperative endoscopy with a Spearman correlation coefficient of 0.796 and a gamma coefficient of 0.94. In addition, the test for accuracy confirmed that the MAGS has the best agreement with the nasopharyngeal assessment of intraoperative endoscopy. Furthermore, a significant correlation between the MAGS and the percentage of choanal obstruction of preoperative endoscopy was also observed with a Spearman correlation coefficient of 0.816 and a gamma coefficient of 0.859. Together, these results reveal that the MAGS is a reliable and precise system for assessment of adenoid size and may be useful as a practical measure for reporting adenoid size in future clinical outcome studies.

It is noted that, although nasal endoscopy is a common method of adenoid size assessment, it still lacks of clinical guideline for subjective description of adenoid size based on endoscopic adenoid view. In publications, the adenoid size was generally determined visually by nasal endoscopy through estimating the choanal obstruction ratio of adenoid tissue based on the subjective assessment of the clinicians [6, 11, 17]. Classification of adenoid size as "small", "moderate" or "large" size can also vary from otolaryngologist to otolaryngologist and is often unreliable [18]. In this study, we chose anatomical landmarks to newly propose an endoscopic adenoid grading system. The use of anatomical landmarks may ensure relatively objective and reproducible evaluation of adenoid size by nasal endoscopy.

Among the existing endoscopy scoring systems, vomer or choana is the most commonly used anatomical landmark. However, although those scoring systems incorporating vomer or choana alone are easy to use and reproducible, they can only offer information of adenoid size at the level of choanal orifices, taking no or less consideration on the depth of the soft tissue under the adenoid tissue. In 2006, Parikh et al. [14] proposed a new grading system for endoscopic examination of adenoid hypertrophy, in which the adenoid size was graded of 1, 2, 3, or 4 according to the anatomical relationships between the adenoid and the three adjacent structures vomer, soft palate, and torus tubaris based on the endoscopic nasopharyngeal image. In a prospective study with a relatively small sample size ($n = 24$), they showed that there was a substantial strength of agreement on the inter-rater reliability of the adenoid grading system [14]. However, the correlation between the system and other existing endoscopic evaluation systems has not been validated. In addition, the designations of the system are not adequately fluid in considering the broad range of torus tubaris that the adenoid may contact. For instance, the adenoid in contact with the posterior edge of torus tubaris (salpingo-pharyngeal fold) and that with the anterior edge of torus tubaris (salpingo-palatine fold) have obvious difference in size, but are both classified into grade 3. This is probably why subsequent study revealed its poor relationship with clinical symptoms and type of tympanometry [15].

Our proposed MAGS was developed upon similar principles as the previous adenoid grading system reported by Parikh et al. [14] by replacing the anatomical landmark torus tubaris with the salpingo-pharyngeal fold (Fig. 1, blue dash line) and the salpingo-palatine fold (Fig. 1, green dash line), but the MAGS preserves the familiarity of the widely used anatomical landmarks, including vomer and soft palate, by retaining the two of its four existing scoring categories. As a result, our assessment showed that the newly proposed system MAGS had high inter-rater reliability and significantly correlated to the percentage of nasopharyngeal obstruction of intraoperative endoscopy, which was considered as the standard in previous studies because of its strong correlation with volume of adenoid tissue and endoscopic nasopharyngoscopy [12, 16]. Moreover, as revealed in Fig. 5, the choanal obstruction measure generated from preoperative endoscopy appeared to overestimate the degree of adenoid size measured by intraoperative endoscopy. Together, these results support the modification of the anatomical landmarks from the previous system, and suggest that the MAGS is a reliable scoring system in reflecting true adenoid size. However, we did not analyze the relationship of the MAGS with clinical symptoms, since the children enrolled in the study frequently co-presented chronic sinusitis, which is another major factor contributing to nasal obstruction and chronic month breathing. Future study with exclusion of obvious rhinitis and sinusitis would be better to determine the performance of the MAGS.

There are also several other limitations in this study. First, intra-rater reliability analysis of the MAGS is lacking. Second, we did not include other clinical parameters, such as clinical symptoms and rhinomanometry, to validate the MAGS in our study. Third, the learning curve for the grading system was not taken into account, which may influence the strength of the agreement of the MAGS. Fourth, the patients in this study were all recruited from a tertiary academic hospital and may not be representative of other medical care settings. Further studies are needed to address these limitations.

Conclusions

In summary, our preliminary study provides the evidence that the MAGS has high reliability and validity for assessment of adenoid size. It may be a more suitable and reliable grading system for endoscopic evaluation of adenoid size.

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Declarations

Conflict of interest No conflicts of interest to declare.

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