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Diagnostic accuracy of the nasal obstruction index in detecting adenoid hypertrophy in children without allergy

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ABSTRACT

Objective: We have previously compared the capacity of the nasal obstruction index (NOI) and nasal fiberoptic endoscopy (NFE) to detect adenoid hypertrophy (AH) in children and found no agreement between them. However, the prevalence of false positive results was significantly higher in children with allergic rhinitis (AR), thus suggesting that AR may be a possible causative factor. The aim of this study was to verify the diagnostic accuracy of the NOI in detecting AH by comparing NOI scores with NFE findings in a selected series of non-allergic children affected by nasal obstruction.

Methods: This prospective study was carried out at the Outpatient Clinics of the Departments of Specialist Surgical Sciences and Maternal and Pediatric Sciences of the University of Milan, Italy, and involved 154 non-allergic children aged 3–12 years in whom otological diseases and/or perceived nasal obstruction led to the suspicion of adenoid obstruction. The diagnostic accuracy of NOI was tested at all of the thresholds obtained by combining all of the cut-off points of NFE and NOI.

Results: Sixty-two percent of the children had otological diseases. The choanal opening was completely blocked by the adenoids in 40% of the children, whereas NOI indicated severe clinical obstruction in only 16%. The analysis of diagnostic accuracy showed that sensitivity and specificity were respectively 17–96% and 15–91% depending on the threshold, with no simultaneously acceptable sensitivity and specificity values at any threshold and AUC values of ≤ 0.7 at all thresholds.

Conclusions: In comparison with NFE, the NOI seems to be inaccurate in detecting AH in non-allergic children with nasal obstruction.

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1. Introduction

As the adenoids lie in the roof of the nasopharynx, it is difficult to make a purely clinical diagnosis of adenoid hypertrophy (AH) in children. One of the clinical scoring systems used to predict AH non-invasively [1,2] is the nasal obstruction index (NOI) of Paradise et al. [2], which was first proposed in 1998 and is based on the degree of mouth breathing and speech hyponasality.

However, the diagnostic usefulness of such systems has been challenged by the availability of nasal fiberoptic endoscopy (NFE), which allows a direct and dynamic evaluation of the nasopharynx with minimal patient discomfort [3,4]. We have previously compared NOI scores with NFE findings in children with AH, and found no agreement between them [5]. However, the

prevalence of false positive results was significantly higher in children with allergic rhinitis (AR) than in those without allergies, which indicates that AR may be a possible causative factor and therefore needs to be identified in order to stratify patients correctly and plan appropriate treatment. It has been found that nasal obstruction is significantly worse in children with AR than in those without [6], and that its appropriate treatment can prevent the development and reduce the severity [7] of obstructive sleep apnea syndrome, which is frequent in children with enlarged adenoids [8].

The aim of the present study was to verify the diagnostic accuracy of the NOI in a selected series of non-allergic children with AH by comparing their NOI scores with the findings of NFE at all of the cut-off points of both systems.

2. Patients and methods

This cross-sectional study involved 154 children aged 3–12 years in whom AH was suspected on the basis of the presence of otitis media with effusion (OME) for at least three months without any sign of acute concomitant inflammation [9], recurrent otitis

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media (RAOM: i.e. a history of at least three documented episodes in the previous six months or at least four in the previous year) [9] and/or perceived nasal obstruction causing sleep disordered breathing (classified by the American Thoracic Society as ranging from persistent snoring for more than three months to obstructive sleep apnea) [10].

The exclusion criteria were allergic rhinitis (documented on the basis of skin prick testing for respiratory allergens), the co-existence of craniofacial, neuromuscular, syndromic or defined genetic abnormalities, previous adenoidectomy or sino-nasal surgery, and any upper respiratory tract infection in the previous 14 days.

The study was approved by our local Ethics Committee, and the children's parents or legal guardians gave their written informed consent.

2.1. Study setting

The study was carried out between October 2007 and October 2008 at the Departments of Specialist Surgical Sciences and Maternal and Pediatric Sciences of Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, University of Milan, Italy.

2.2. Interventions

Upon enrolment, a complete clinical history was taken, and the children underwent a pediatric, otolaryngological and clinical assessment based on skin prick testing for respiratory allergens.

The NOI was calculated for all of the children by the same examiner (P.M.) in accordance with Paradise et al. [2], and scored as 1, no clinical obstruction; 2, mild clinical obstruction; 3, moderate clinical obstruction; and 4, severe clinical obstruction. Mouth breathing was assessed by means of direct observation when the child was distracted and still, and speech hyponasality was tested by listening to the child repeat standard Italian test phrases containing nasal phonemes (i.e. “la mia nonna fa la nanna” and “novantanove banane”) with the nostrils open and closed in order to detect any difference in nasal resonance. Mouth breathing and hyponasality were both scored using a 4-point scale: 1, absent; 2, mild; 3, moderate; 4, marked.

The NFE findings of AH were graded 1, a free choanal opening; 2, adenoids occluding the upper half of the choanal opening without tubarian ostium involvement; 3, adenoids occluding 75% percent of the choanal opening with partial tubarian ostium involvement; and 4, adenoids completely occluding the choanal opening with an unevaluable tubarian ostium [11] (Fig. 1).

2.3. Statistical analysis

The diagnostic accuracy of NOI was compared with the NFE findings at each of the cut-off points of both techniques (Table 1), and the sensitivity and specificity, positive (PPV) and negative predictive values (NPV), positive (PLR) and negative likelihood ratios (NLR), and the area under the ROC curve (AUC) were computed with their respective 95% confidence intervals at every

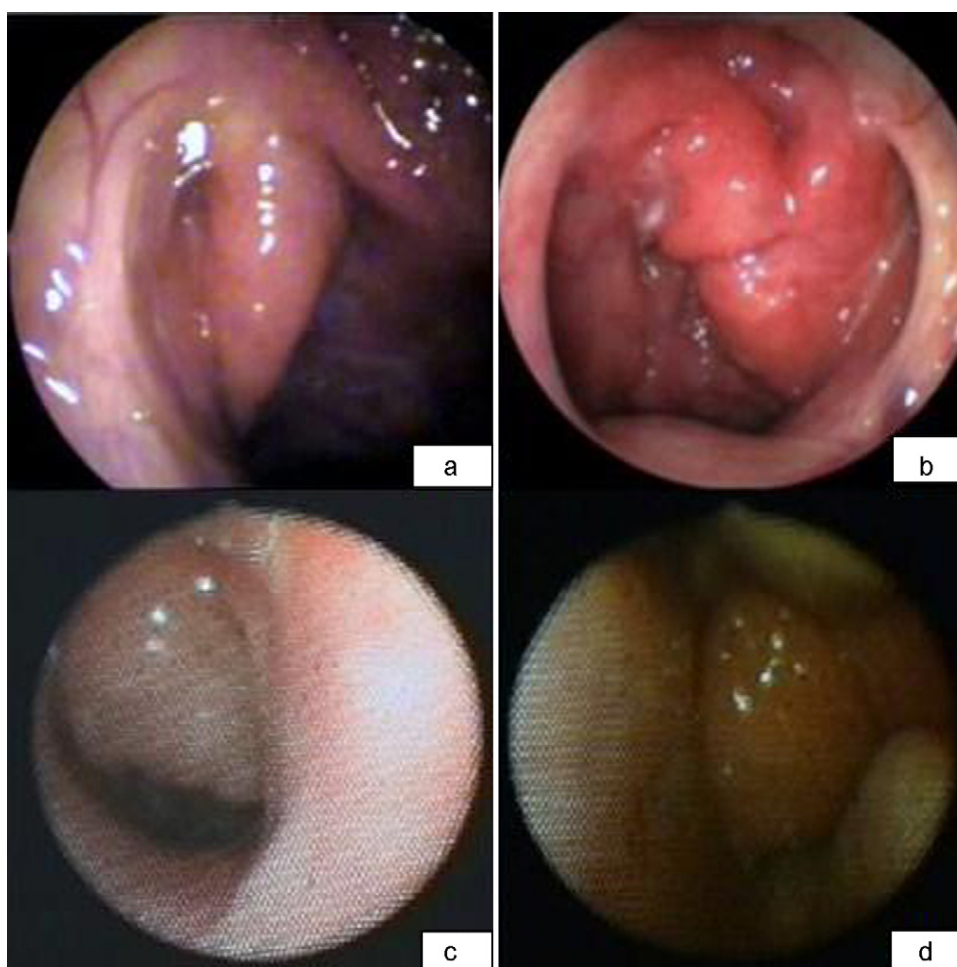


Fig. 1. NFE findings showing: (a) AH grade 1: free choanal opening; (b) AH grade 2: adenoids occluding the upper half of the choanal opening without tubarian ostium involvement; (c) AH grade 3: adenoids occluding 75% percent of the choanal opening with partial tubarian ostium involvement; and (d) AH grade 4: adenoids completely occluding the choanal opening with an unevaluable tubarian ostium.

Table 1

Study thresholds determined by combining all of the cut-off points of NFE and NOI.

Threshold	NFE cut-off points	NOI cut-off points
1	1	1
2	1	2
3	1	3
4	2	1
5	2	2
6	2	3
7	3	1
8	3	2
9	3	3

NFE: nasal fiberoptic endoscopy; NOI: nasal obstruction index.

threshold obtained by combining all of the cut-off points of NFE and NOI.

The data were analysed using STATA 10.0 software (StataCorp, 4905 Lakeway Drive, College Station, Texas 77845, USA).

3. Results

Of the 213 patients assessed for eligibility, 59 were excluded from the study for various reasons (see Fig. 2), and so the final analysis was based on the data relating to 154 patients. Table 2 shows the demographic and clinical characteristics of the study population, and Fig. 3 shows the relative prevalence of the NOI and NFE classes. Most of the patients (62%) had otological diseases. NFE showed that the choanal opening was completely blocked by the adenoids in 40% of the children (grade 4), whereas NOI indicated severe clinical obstruction (NOI = 4) in only 16%.

Table 3 shows the diagnostic accuracy of NOI in relation to NFE at each threshold. Sensitivity and specificity were respectively 17–96% and 15–91%, depending on the threshold: the higher the NFE cut-off point, the lower the sensitivity (with an increased number of false negative results), and the higher the NOI cut-off point, the lower the specificity (with an increased number of false positive

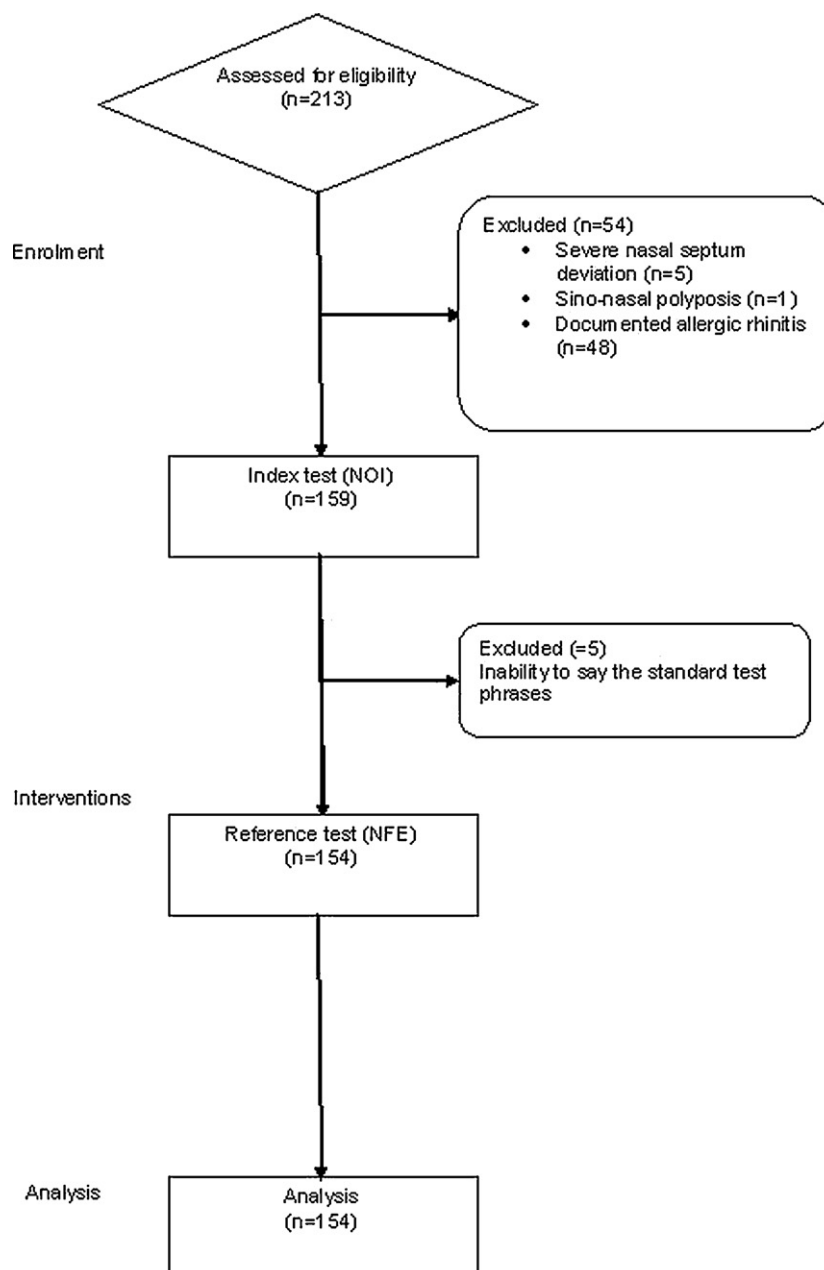
**Fig. 2.** Study flow-chart.

Table 2

Demographic and clinical characteristics of the 154 children in the study population.

Variable	%
Males	53.3
Mean age, years (SD)	5.4 (1.8)
Otological disease	62.0
OME	36.8
RAOM	25.2
Perceived nasal obstruction	38.0

SD: standard deviation; OME: otitis media with effusion; RAOM: recurrent acute otitis media.

results). There were no simultaneously acceptable sensitivity and specificity values at any threshold.

The PPVs were inadequate at most of the thresholds, being >90% only in the case of thresholds 2 and 3. The lower the NFE cut-off point, the higher the PPV; at the same NFE cut-off point, PPVs were slightly lower at a NOI cut-off point of 1, and there was no difference in the PPVs at NOI cut-off points 2 and 3.

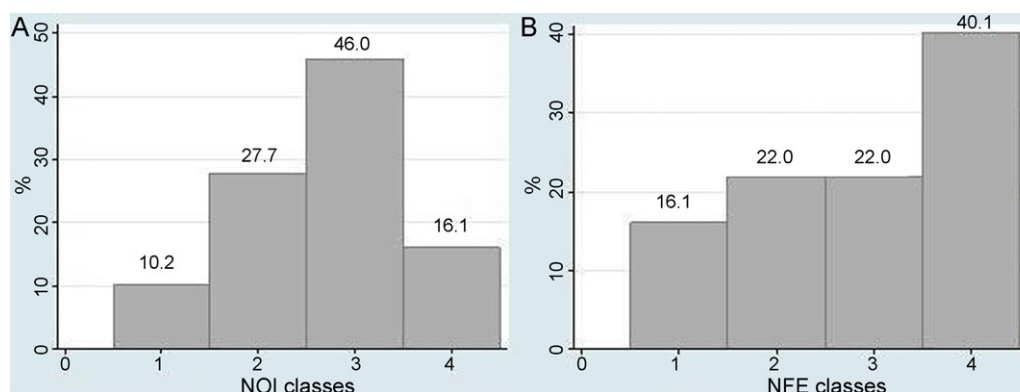
In comparison with NFE, the NOI was inaccurate in predicting AH at each threshold (AUC values 0.5–0.7) [12].

4. Discussion

Diagnosing AH is clinically challenging and, despite the disadvantage that it exposes children to radiation, the most widely used method in clinical practice is plain nasopharyngeal radiography [13]; however, NFE is more accurate and better correlates with symptom severity [3].

In a previous study [5], we compared NFE findings with a NOI-based clinical assessment of AH in children aged 3–12 years with persistent/recurrent otitis media or perceived obstructive nasal breathing, and found that NOI was inaccurate in predicting the degree of adenoidal obstruction. However, although we excluded potential confounding factors (craniofacial, neuromuscular, syndromic or defined genetic abnormalities; previous adenoidectomy or sinonasal surgery; upper respiratory tract infection in the previous 14 days; and nasal malformations, polyposis or tumours), as well as children unable to cooperate during the clinical assessment, about 24% of the subjects were allergic and it has been reported that false positive results are significantly more frequent in children with allergies (50% vs. 22.4%, $P = 0.009$). This suggests that allergies should be considered among the causes of more anterior nasal obstructions that cannot be explained by adenoid size, particularly as it has been reported that nasal obstruction is significantly worse in children with AR than in those without [6].

On the basis of these considerations, and as recently pointed out by Paradise [14], it can be argued that the inclusion of allergic children in our previous study may have partially biased the results. However, our latest findings indicate that the NOI is also uninformative in the case of non-allergic children, as shown by the poor AUCs of 0.5–0.7 [12]. Analysis of the thresholds based on all of the MFE and NOI results showed that NOI sensitivity and specificity varied widely (17–96% and 15–91%), and that there were no simultaneously acceptable sensitivity and specificity values at any threshold: the higher the NFE cut-off point, the lower the sensitivity (an increased number of false negative results), and the higher the NOI cut-off point, the lower the specificity because of the increase in false positive results.

**Fig. 3.** Relative prevalence of NOI (a) and NFE classes (b) in the study population.**Table 3**

Measures of diagnostic accuracy for each threshold.

Threshold	NFE cut-off point	NOI cut-off point	Sensitivity, % (95% CI)	Specificity, % (95% CI)	PPV, % (95% CI)	NPV, % (95% CI)	PLR, % (95% CI)	NLR, % (95% CI)	AUC (95% CI)
1	1	1	93.0 (88.4–97.7)	27.3 (8.7–45.9)	87.0 (81.0–92.9)	42.9 (16.9–68.8)	1.3 (1.0–1.7)	0.2 (0.1–0.7)	0.6 (0.5–0.7)
2	1	2	67.8 (48.7–87.6)	68.2 (48.7–87.6)	91.8 (85.9–97.6)	28.8 (16.5–41.2)	2.1 (1.1–4.0)	0.4 (0.3–0.7)	0.7 (0.6–0.8)
3	1	3	17.4 (10.5–24.3)	90.9 (78.9–100)	91.9 (78.9–100)	17.4 (10.5–24.3)	1.9 (0.5–7.6)	0.9 (0.8–1.1)	0.5 (0.5–0.6)
4	2	1	96.5 (92.5–100)	21.1 (10.0–32.2)	66.7 (58.3–75.0)	78.6 (57.1–100)	1.2 (1.1–1.4)	0.2 (0.1–0.6)	0.6 (0.5–0.6)
5	2	2	77.6 (68.8–86.5)	63.5 (50.4–76.5)	77.6 (68.8–86.5)	63.5 (50.4–76.5)	2.1 (1.5–3.1)	0.3 (0.2–0.5)	0.7 (0.6–0.8)
6	2	3	18.8 (10.5–21.1)	88.5 (79.8–97.1)	72.7 (54.1–91.3)	40.0 (31.0–49.0)	1.6 (0.7–3.9)	0.9 (0.8–1.1)	0.5 (0.5–0.6)
7	3	1	96.4 (91.4–100)	14.6 (7.0–22.3)	43.1 (34.3–51.8)	85.7 (67.4–100)	1.1 (1.1–1.2)	0.2 (0.1–1.1)	0.5 (0.5–0.6)
8	3	2	81.8 (71.6–92.0)	51.2 (40.4–62.0)	52.9 (42.3–63.5)	80.8 (70.1–91.5)	1.7 (1.3–2.2)	0.3 (0.2–0.6)	0.7 (0.6–0.7)
9	3	3	21.8 (10.9–32.7)	87.8 (80.7–94.9)	55.5 (33.7–75.3)	62.6 (53.8–71.4)	1.8 (0.8–3.8)	0.9 (0.8–1.0)	0.5 (0.5–0.6)

NFE: nasal fiberoptic endoscopy; NOI: nasal obstruction index; 95% CI: 95% confidence interval; PPV: positive predictive value; NPV: negative predictive value; PLR: positive likelihood ratio; NLR: negative likelihood ratio; AUC: area under the ROC curve.

5. Conclusions

On the basis of our findings, in comparison with NFE, the NOI seems to be inaccurate in detecting AH in non-allergic children with nasal obstruction. NFE should therefore be considered the first-level diagnostic means of choice in the case of all children in whom AH is suspected on the grounds of nasal obstruction and/or otological diseases.

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