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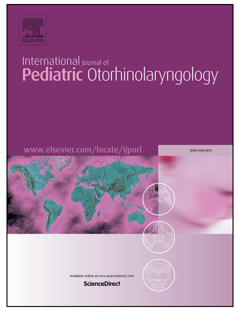


What is the relationship between the size of the adenoids and nasal obstruction? A systematic review

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**Article Title**:

What is the relationship between the size of the adenoids and nasal obstruction? A systematic review.

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**Compliance with Ethical Standards:**

- Founding source: none
- All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.
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# Abstract

**OBJECTIVE**: adenoidectomy is one of the most common surgical procedure in pediatric otolaryngology practice. Clinical guidelines (such as the Spanish or American) suggest adenoidectomy when the enlargement of the adenoids is associated with nasal obstruction. Nasal endoscopy and cephalograms are adequate methods to estimate the size of the adenoids. However, they do not measure nasal patency. This systematic review is designed with the objective of exploring the relationship between adenoid size and nasal ventilation through rhinomanometry.

**REVIEW METHODS**: 3 authors members of the YO-IFOS rhinology study group independently analyzed the data sources (Pubmed, the Cochrane Library, EMBASE, SciELO) for papers assessing both nasal resistance and/or nasal airflow in rhinomanometry and adenoid size by any method (endoscopy, cephalogram, direct examination).

**RESULTS**: A total of 10 studies with a total population of 969 participants met the inclusion criteria. 5 authors explored the size of the adenoids through endoscopy. 4 authors explored the adenoids through lateral cephalograms. Finally, a further 2 authors explored adenoid size studying the resected tissue. Five studies explored the correlation between adenoid size and nasal resistance in rhinomanometry, which ranged from 0.20 and 0.84. Finally, 5 studies used nasal decongestant. It was found higher sensitivity and specificity, a higher area under the curve for the receiver operating characteristic curve, and higher correlation with adenoid size for rhinomanometry under nasal decongestion.

**CONCLUSION**: Up to now, there is no ideal diagnostic method for adenoid hypertrophy. Therefore, it seems prudent to use a combination of all currently available tools, as they provide complementary, rather than supplementary information. Available evidence suggests that rhinomanometry combined with nasal decongestant could help to elucidate the existence of nasal obstruction in intermediate cases of adenoid hypertrophy, as well as throw light on other possible causes for nasal obstruction, mainly turbinate hypertrophy.



***KEYWORDS***

adenoid; rhinomanometry; adenoidectomy; rhinitis

# INTRODUCTION

Nasal obstruction is a clinically relevant problem among pediatric patients, because of its high prevalence as well as for its consequences. Impaired nasal breathing (INB) could bring about pathological conditions such as rhinosinusitis, otitis media with effusion, it exacerbates sleep apnea and, finally, it is a predominant cause of alterations in facial growth.[1–3]

INB might be caused by a variety of conditions, one of the most common being adenoidal hypertrophy (AH).[4] In consequence, adenoidectomy has been widely used as a standard treatment for nasal obstruction.

Clinical guidelines suggest adenoidectomy when the enlargement of the adenoids is associated with nasal obstruction.[5,6] However, they do not specify how this obstruction should be measured and how much obstruction is too much. Therefore, clinicians often make decisions based on physical examinations and symptoms. However, these are surrogates of what clinicians in fact want to know, which is if the hypertrophied adenoids are indeed causing nasal obstruction.

Nasal endoscopy and cephalograms are adequate methods to estimate the size of the adenoids. However, they do not measure nasal patency. Nasal obstruction could be estimated by parental or patient report; nevertheless, children often underestimate their nasal obstruction.[7] It could also be assessed by clinical findings such as hyponasality or stuffiness. Nonetheless, available evidence has shown very little agreement between symptoms and adenoid volume with the possible exception of snoring and mouth breathing.[8] On the other hand, there are the objective measurements, which include exams such as rhinomanometry (RMN), or peak nasal inspiratory flow. Objective examinations might help to overcome the weaknesses of subjective assessments in nasal patency, and thus improve the selection process for adenoidectomy.

RMN, despite several concerns, is currently considered the gold standard test to assess nasal patency.[9] It consists of the simultaneous measurement of nasal airflow and transnasal pressure, which is defined as the difference between the pressure in choanae and the atmosphere. Using those two values, nasal resistance can be calculated through a mathematical formula derived from Ohm's law.

There is some controversy regarding the use of rhinomanometry in the diagnostic process of adenoid hypertrophy. This systematic review is designed with the objective of exploring the relationship between adenoid size and nasal ventilation through rhinomanometry.

# METHODS

This review was performed according to PRISMA guidelines, and a formal PROSPERO protocol was published according to the NHS International Prospective Register of Systematic Review (Nº CRD42021224024) prior to the initiation of the study. We also followed the recommendations of the AMSTAR-2 guidelines.

## ***Literature Search. Inclusion and exclusion criteria***

The criteria for considering studies for this systematic review were based on the population, intervention, comparison, and outcome (PICOTS) framework.

**Participants**: pediatric participants (<18 yo).

**Intervention (diagnostic test)**: adenoid size by any method (endoscopy, cephalogram, direct examination).

**Comparison**: rhinomanometry (bilateral nasal resistance)

**Outcomes**: relationship between bilateral nasal resistance and adenoid size.

**Timing** and **Setting**: without limitation

**Types of studies**: Clinical trials, case series, prospective and retrospective cohort studies published in peer-reviewed journals including more than 10 patients. We did not include case reports, theses, or meetings communications. There were no restrictions by date or publication type, and the search was last updated in January 2021. We included studies published in English, Spanish, German, French, Italian and Portuguese.

**Exclusion criteria**: exclusion criteria consisted of: 1) studies carried out on syndromic patients; 2) dual publications; 3) unilateral nasal resistance data

## ***Search strategy***

The systematic review and electronic search were performed according to the PRISMA Statement recommendations using the following databases: Pubmed (Medline), Cochrane Library, EMBASE, Scopus and SciELO. We used a predefined search strategy described in supplementary data 1. The abstracts of the retrieved papers were thoroughly reviewed by three authors who are members of the YO-IFOS rhinology study group (CCH, BVB, BBC), and those potentially fulfilling the inclusion criteria were selected for full-text review. In case of discrepancies between reviewers regarding the selection of the abstracts, the corresponding papers were included in the full text review stage for a final assessment. We also manually reviewed the references of all selected articles to identify any potentially missing publication.

## ***Study Extraction, Categorization, and Analysis***

Two authors (CCH and AB) independently analyzed the articles that met the inclusion criteria and extracted the relevant data. Extracted variables encompassed: sample size, age, initial diagnosis, method used to measure adenoid size and size of adenoids, method used to measure nasal resistance and main outcome. Nasal resistance is expressed (whenever possible) in Pa s/$cm^3$. Potential discrepancies between investigators were resolved by senior author (CMM).

### *Assessment of study quality*

We assessed the selected articles for both level of evidence and quality. Level of evidence was classified according to the Oxford Centre for Evidence-Based Medicine Levels 2011. The risk of bias was assessed according to the QUADAS-2 tool to assess the risk of diagnostic bias accuracy studies, recommended by the National Institute for Health and Clinical Excellence.[10]

### *Statistical analysis*

Data was analyzed with STATA for Macintosh v. 15.1 (StataCorp ®). The Cochrane Collaboration's Review Manager Software (REVMAN) version 5.4 (Nordic Cochrane Centre, Cochrane Collaboration, 2020, Copenhagen, Denmark) was initially planned to be used to conduct the meta-analysis. However, the metanalysis could not be performed.

# RESULTS

## *Search results*

A flowchart of the search process is shown in Figure 1. The initial search retrieved 206 publications. From them, 26 studies were selected for full text review. A total of 10 studies with a total population of 969 participants met the inclusion criteria.

Of the 26 papers selected for full-text reading, 16 publications were excluded for the following reasons (references in supplementary data 2): 1 included adults; 2 adenoids were not independently studied; 9 adenoid size was not assessed; 3 rhinomanometry was not performed; 1 the relationship between adenoid size and rhinomanometry was not assessed.

## *Results of the included studies*

A summary of the selected studies is presented in table 1.

Ten studies were selected[11–20]. Among them, mean sample size was 96.9, with the highest (n=284) reported by Zicari *et al*,[13] and the lowest (n=24) by Sørensen *et al*.[20] Only six studies provided mean age, thus, given this limitation, mean age adjusted by sample size is 9.28 years old, being the lowest 5.2 from Cassano *et al*,[16] and the highest 10.6 from both studies by Zicari *et al*.[13,14]

Five authors explored the size of the adenoids through endoscopy,[11–14,16] four of which used Cassano's classification.[11,13,14,16] All of them presented data in different ways, which prevent us from combining their results in a metanalysis. Four authors explored the adenoids through lateral cephalograms.[15,17,18,20] They all used a variety of measurements to assess adenoid size. It is noteworthy that Kobayashi *et al* did not provide individual data, as they categorized the A/N ratio (a=adenoid size, n=nasopharynx size) variable.[15] Neither did Thüer *et al* provide their data regarding x-ray assessment of the rhinopharynx.[17] Therefore only two authors provided individual data, which cannot be merged in a metanalysis. Finally, a further two authors explored adenoid size studying the resected tissue.[18,19]

Five studies explored the correlation between adenoid size and nasal resistance in rhinomanometry.[13,14,18–20] The correlation ranged from 0.20 considering the linear measurement of adenoid depth in lateral cephalograms;[18] and 0.84 when considering small adenoids in endoscopy (Cassano 0 and 1) .[13]

Furthermore, five studies used nasal decongestant.[13,14,17,18,20] Amongst these, three explored the differences between rhinomanometry in basal conditions and under nasal decongestion.[13,14,17] Both studies by Zicari *et al* found higher sensitivity and specificity, a higher area under the curve for the receiver operating characteristic curve, and higher correlation with adenoid size for rhinomanometry under nasal decongestion.[13,14] In contrast, Thüer *et al*, did not find any association between the adenoids in lateral cephalograms and rhinomanometry with or without nasal decongestion.[17]

### ***Quality and level of evidence***

All the included papers had a level of evidence of 3 according to the Oxford center of evidence based medicine 2011, with the exception of Cassano *et al*,[16] as they followed a case-control design.

The risk of bias is summarized in table 2. Several points could not be assessed as authors did not specify them in their methods section. The most unreported item was 4-A1 (Was there an appropriate interval between index test and reference standard?), only reported by Cassano et al;[16] and 4-A5 (Could the patient's flow have introduced bias?), only reported by Cassano et al and Fielder et al.[16,19]

# DISCUSSION

We found a low to moderate correlation between the size of the adenoids and nasal resistance, which tends to increase for the extremes of adenoid size (small and large adenoids), and to improve with the use of nasal decongestant. These results suggest that, in cases where very small or very large adenoids are present, no objective assessment of nasal ventilation is required. However, for cases in between the extremes, RMN with nasal decongestant could be a complementary test added to the patient's medical history, as well as a physical examination.

The main concern is that there is no gold standard test to compare the results of RMN. In order to stablish the validity of the test, sensitivity, specificity, and true and false positive ratios should be calculated. In order to do that, a Gold Standard test, with the capacity to produce unequivocal diagnoses is required, and none currently exist. In consequence, it is hard to stablish the usefulness of RMN in the diagnosis process of adenoid hypertrophy. RMN itself has some weaknesses which should be taken into account. One of the main problems is the time required to carry out the test, which may take up to 20 or 30 minutes. The second concern is which type of RMN should be used. Ideally, posterior RMN ought to be chosen, instead of anterior, as it measures the resistance under the adenoid pad and not in front of it.[21] However, posterior RMN is not easily tolerated by children, as it entails placing a plastic tube in the oropharynx.[18] Despite this difference, a previous study demonstrated that even when posterior RMN determinations were consistently higher than those obtained by the anterior technique, the degree of association between them was high.[21] The third issue is that normal resistance values vary with age,[22] which can make interpretation difficult for cases in the limit of normality.

Even with its known limitations, RMN is, nowadays, the recommended objective test when performing research,[23] and has been widely used to assess the results of nasal interventions in children.

This systematic review found ten studies evaluating the relationship between adenoid size and rhinomanometry. Adenoid size could be assessed through a cephalogram, nasendoscopy or direct examination of surgical specimens.

When considering the studies exploring adenoid size through endoscopy, all authors, with the exception of Rybnikar *et al,* found a significant association with rhinomanometry.[12] Nasoendoscopy has drawbacks as well; mainly, it allows little opportunity for objective measurement but instead relies on professional opinion, often causing low interobserver agreement.[24] Among the five authors who explored the adenoids through endoscopy, only Zicari *et al* studied the correlation between rhinomanometry and adenoid size. They used the Cassano's classification and performed rhinomanometry with and without nasal decongestant. They found a significant correlation for grade 0 (0.84), and 4 in endoscopy (0.79) with nasal resistance in rhinomanometry under nasal decongestant. This correlation was low without nasal decongestion.[13] These results, therefore, suggest that nasal endoscopy is an adequate tool to predict the severity of nasal obstruction in extreme cases (small and large adenoids) but not in middle-of-the-range cases and they also highlight the importance of nasal decongestion. RMN under nasal decongestion is of paramount importance as symptoms of nasal airway obstruction by adenoid hypertrophy may overlap with symptoms of nasal mucosa inflammation such as turbinate hypertrophy. If nasal resistance after nasal decongestion remains high, structural causes of nasal obstruction should be explored. RMN with nasal decongestion is proven to be a useful test for clinicians in terms of choosing the correct treatment and avoiding unnecessary adenoidectomies in children, or incomplete surgeries, as turbinate surgery might be added to adenoidectomy if part of the obstruction is explained by turbinate hypertrophy.[25]

Similar results were obtained by Cassano *et al*.[16] Despite the fact that they did not perform a correlation study, they found an evident progressive worsening of nasal resistance with the increase in size of the adenoids, being normal in 100% of cases with grade 1, and 100% abnormal in patients with grade 4. In the intermediate cases (grades 2 and 3) there were variable degrees of nasal obstruction, which suggests that rhinomanometry is especially useful in those instances.

Other authors found increased nasal resistance with small adenoids. Sojak *et al* studied children undergoing adenoidectomy using Cassano's classification through nasal endoscopy. They did not have enough children for groups 1 and 4, so they divided their sample in group I (grades 1 and 2) and group II (grades 3 and 4). They found increased nasal resistance (without nasal decongestant) for the second group. However, nasal resistance was still high for group I (0.52) highlighting that other causes of nasal obstruction should have been investigated.[11] Similar results were found by Di Rienzo *et al*, who found persistence of some adenoid tissue after cold curettage (grade 1.8). Nonetheless, even in adenoids this small in size, the nasal resistance was high.[26]

Rybnikar *et al*, was the only author who did not find any link between adenoid size and rhinomanometry. They studied children before and after adenoidectomy and divided the sample in three groups according to the Wormald-Prescott classification of the adenoids. It is noteworthy that nasal resistance (without nasal decongestion) was almost normal for all the studied groups, which poses a question about the indication for surgery in those patients, as no specific notes were given in this regard.[12]

Four authors explored the adenoids through cephalograms. There are several ways to assess adenoids in x-rays, but no current consensus on which is the best.[27] Three authors calculated correlation values between adenoid in the cephalograms and nasal resistance.[15,18,20] However, their correlation values were lower than those found in nasal endoscopy under nasal decongestion. Parker *et al* found a significant but low correlation between nasal resistance under nasal decongestion and palatal airway size (-0.35) and adenoid depth (0.20).[18] Similar results were found by Kobayashi *et al* (0.35) using basal rhinomanometry (without decongestion).[15] Different from the others, Sørensen *et al*, in a cohort of children undergoing adenoidectomy, found a higher correlation, both for rhinopharynx airway (-0.52) and adenoid size (0.58) in cephalograms of cases presenting nasal resistance under nasal decongestion.[20]

The study of Vig *et al* is noteworthy, albeit not part of this review as it included adults, given that they found low sensitivity and high specificity when using cephalograms to predict nasal obstruction.[28] This finding is similar to that found for endoscopy, which suggests that complete obstruction of the choana is closely related to nasal obstruction, while other degrees of adenoid size lead to variable degrees of nasal obstruction.

In contrast to the rest of authors, Thüer *et al* did not find any relationship between cephalogram variables and nasal resistance through posterior rhinomanometry.[17] Nevertheless, the methodology employed was not appropriate to address this question as they used a sample of children with malocclusion, which is, itself, a cause of nasal obstruction and they did not explored other causes of INB.[29]

Finally, two authors explored the correlation between rhinomanometry and the amount of resected tissue. Parker *et al* found a significant but low correlation with nasal resistance (0.30),[18] as did Fielder *et al* (0.35).[19] Interestingly, Fielder *et al* found a subgroup of patients with a large reduction in nasal resistance but small adenoids,[19] which reinforces the idea that rhinomanometry is especially useful in intermediate cases of adenoid hypertrophy.

In summary, available evidence suggests a relationship between nasal resistance and adenoid size. This relationship is higher for extreme cases (small and large adenoids) and when nasal decongestion is used. In intermediate cases, the size of the adenoids is a poor indicator of nasal obstruction. This could be explained by several reasons. First, there could be other overlooked causes such as turbinate hypertrophy or maxillary constriction. Also, the shape of the adenoids might be more important than their size. Cassano *et al* found both high and low resistance values in cases of adenoids grade II and III, which suggests that equally sized adenoids do not always cause the same degree of obstruction.[16]

The use of nasal decongestion is of paramount importance in order to eliminate some confounding factors. Two-thirds of the total nasal resistance is at the level of the pyriform aperture. Therefore, part of the nasal obstruction could be better explained by anterior causes, such as turbinate hypertrophy. Cassano *et al* found that 66% of their sample had mucous-purulent rhinitis, which might introduce a bias in the assessment of nasal obstruction.[16] For this reason, the criterion of a poor response to decongestion was suggested by Juliusson *et al* as having a predictive value in the preoperative selection of children most likely to have chronic upper airway obstruction problems solved by adenoidectomy.[30] They divided their sample in responders and non-responders for adenoidectomy. Their results indicated no differences in basal rhinomanometry, but when performed under nasal decongestion differences were found.[30] They concluded that preoperative nasal airway resistance after nasal decongestants was lower in the non-responders, which would indicate that their problems were not due to enlarged adenoids but to nasal mucosa congestion.

However, all above-mentioned examinations, either rhinomanometry, cephalogram or endoscopy, are surrogates for what clinicians really want to know, which is if the children's symptoms and quality of life will improve. The selected studies have not explored the correlation between rhinomanometry and symptoms of adenoid hypertrophy. Nevertheless, it is noteworthy to mention the study by Juliusson *et al*, who found that adenoidectomy was most effective in terms of parental reporting of nasal symptoms in those patients with high preoperative nasal resistance values which remained essentially unchanged following topical vasoconstriction.[30]

### ***Limitations***

The primary limitation of this paper is the low number of included studies, which may negatively impact the review results. Secondly, the studies included children based on different inclusion criteria. In consequence, it is possible that our results would have been biased by the heterogeneity related to study differences. Thirdly, we were not able to limit or even perform a subgroup analysis to younger children. In consequence, we have included patients of different ages, which could not be representative of our aim, that is younger children. Finally, conclusions drawn from systematic reviews inevitably depend on the quality of the included studies.

## Conclusions

Up to now, there have been no ideal diagnostic method for adenoid hypertrophy. Therefore, it seems prudent to use a combination of all currently available tools, as they provide complementary, rather than supplementary information. Relying only on the size of the adenoid is imprudent, as this does not take into account the whole clinical picture. Available evidence suggests that rhinomanometry combined with nasal decongestant could help to elucidate the existence of nasal obstruction in intermediate cases of adenoid hypertrophy, as well as throw light on other possible causes for nasal obstruction, mainly turbinate hypertrophy.

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**Legend for figures**

Figure 1: PRISMA flowchart

**Legend for tables:**

Table 1 - Description of the included studies. NA (not applicable). NR (not reported). AAR (anterior active rhinomanometry). PAR (posterior active rhinomanometry). ND (nasal decongestion)

Table 2 Assessment of the risk of bias (NICE guidelines, appendix F).

1A-1 Was a consecutive or random sample of patients enrolled? / 1A-2: Was a case-control design avoided? / 1A-3: Did the study avoid inappropriate exclusions? / 1A-4: Could the selection of patients have introduced bias? / 1B: Is there concern that the included patients do not match the review question? / 2A1-Were the index test results interpreted without knowledge of the results of the reference standard? / 2A2: If a threshold was used, was it pre-specified? / 2A3: Could the conduct or interpretation of the index test have introduced bias? / 2B1: Is there concern that the index test, its conduct, or interpretation differ from the review question? / 3A1: Is the reference standard likely to correctly classify the target condition? / 3A2: Were the reference standard results interpreted without knowledge of the results of the index test? / 3A3: Could the reference standard, its conduct, or its interpretation have introduced bias? / 3B1: Is there concern that the target condition as defined by the reference standard does not match the review question?

*Table 1 - Description of the included studies. NA (not applicable). NR (not reported). AAR (anterior active rhinomanometry). PAR (posterior active rhinomanometry). ND (nasal decongestion)*

| **Author (Year)** | **Design / Level of evidence** | **Cohort** | **Initial diagnosis** | **Sample size and sex** | **Age (years). Mean ± SD (range)** | **Size assessment** | **Decongestion** | **Rhinomanometric value** | | **Main finding** |
|---|---|---|---|---|---|---|---|---|---|---|
| Sojak J *et al* 2018 | Quasi-experimental study<br>Level 3 | Pre-adenoidectomy | Chronic nasal obstruction | 29 (NR) | NR ± NR (3-15) | Endoscopy (Cassano) 1-2 | None (basal) | Nasal resistance (AAR at 150 Pa) (Pa / s. cm$^3$) | 0.52 ± NR | SSD after adenoidectomy for children with big adenoids (Cassano 3 and 4) but not for those with small adenoids (Cassano 1 and 2). |
| | | | | 21 (NR) | | Endoscopy (Cassano) 3-4 | | Nasal resistance (AAR at 150 Pa) (Pa / s. cm$^3$) | 0.62 ± NR | |
| | | Post-adenoidectomy | | 29 (NR) | | Endoscopy (Cassano) 1-2 | | Nasal resistance (AAR at 150 Pa) (Pa / s. cm$^3$) | 0.54 ± NR | |
| | | | | 21 (NR) | | Endoscopy (Cassano) 3-4 | | Nasal resistance (AAR at 150 Pa) (Pa / s. cm$^3$) | 0.44 ± NR | |
| Rybnikar T *et al* 2018 | Quasi-experimental study<br>Level 3 | Pre-adenoidectomy | Symptoms of adenoid hypertrophy | 12 (7 M, 5 F) | 11.1 ± NR (6.0-17.9) | Endoscopy (Wormald-Prescott) Grade I | None (basal) | Nasal resistance (AAR at 150 Pa) (Pa / s. cm$^3$) | 0.34 ± NR (0.30-0.38) | SSD in nasal resistance before and after adenoidectomy only for grade III adenoids. No SSD for adenoid grade I and II.<br>No differences in resistance values between grade I, II and III of adenoids. |
| | | | | 21 (7 M, 14 F) | 8.9 ± NR (5.1-16.2) | Endoscopy (Wormald-Prescott) Grade II | None (basal) | Nasal resistance (AAR at 150 Pa) (Pa / s. cm$^3$) | 0.32 ± NR (0.26-0.51) | |
| | | | | 15 (6 M, 9 F) | 9.3 ± NR (6.1-17.3) | Endoscopy (Wormald-Prescott) Grade III | None (basal) | Nasal resistance (AAR at 150 Pa) (Pa / s. cm$^3$) | 0.35 ± NR (0.31-0.46) | |
| | | Post-adenoidectomy | | 12 (7 M, 5 F) | 11.1 ± NR (6.0-17.9) | Endoscopy (Wormald-Prescott) Grade I | None (basal) | Nasal resistance (AAR at 150 Pa) (Pa / s. cm$^3$) | 0.31 ± NR (0.22-0.39) | |

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|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 21 (7 M, 14 F) | 8.9 ± NR (5.1-16.2) | Endoscopy (Wormald-Prescott) Grade II | None (basal) | Nasal resistance (AAR at 150 Pa) (Pa / s. $cm^3$) | 0.29 ± NR (0.18-0.39) | |
| | | | | 15 (6 M, 9 F) | 9.3 ± NR (6.1-17.3) | Endoscopy (Wormald-Prescott) Grade III | None (basal) | Nasal resistance (AAR at 150 Pa) (Pa / s. $cm^3$) | 0.31 ± NR (0.19-0.44) | |
| Kobayashi R *et al* 2013 | Case-Control study<br>Level 4 | Healthy controls | Children selected from a routine screening | 80 (NR) | NR ± NR (NR) | Lateral cephalogram A/N ratio <0.55 | None (basal) | Nasal resistance (AAR at 100 Pa) (Pa / s. $cm^3$) | 0.46 ± 0.24 | Nasal resistance is higher in children with adenoid hypertrophy according to A/N ratio in the cephalogram (SSD). |
| | | Adenoid hypertrophy | | 72 (NR) | NR ± NR (NR) | Lateral cephalogram A/N ratio ≥ 0.55 | None (basal) | Nasal resistance (AAR at 100 Pa) (Pa / s. $cm^3$) | 0.32 ± 0.10 | |
| Zicari AM *et al* 2013 | Cross-Sectional study<br>Level 3 | NA | Habitual snorers | 284 (168 M, 132 F) | 10.6 ± NR (6-12) | Endoscopy (Cassano)<br>- grade 0 (29.2%)<br>- grade 1 (28.7%)<br>- grade 2 (17.9%)<br>- grade 3 (11.9%)<br>- grade 4 (15.1%) | None (basal) | Nasal resistance (AAR at 150 Pa) (Pa / s. cm3) | - grade 1 (35.9%)<br>- grade 2 (14.4%)<br>- grade 3 (18.3%)<br>- grade 4 (13%)<br>- grade 5 (18.3%) | SS correlation for resistance grade 0,1 and adenoids grade 0 (0.84), and resistance grade 5 and adenoids grade 4 (0.79) under ND. Low correlation without ND.<br><u>ROC curve</u>: AUC=0.827 for RMN with ND, and 0.629 for basal RMN. |
| | | | | | | | Decongestant (Xylometazoline 0.05% 2 drops/nostril) | Nasal resistance (AAR at 150 Pa) (Pa / s. cm3) | - grade 1 (38%)<br>- grade 2 (18.3%)<br>- grade 3 (19.7%)<br>- grade 4 (8.1%)<br>- grade 5 (15.8%) | |
| Zicari AM *et al* 2012 | Cross-Sectional study<br>Level 3 | Habitual snorers | Upper airway obstructive symptoms | 71 (43 M, 28 F) | 10.6 ± NR (6-12) | Endoscopy (Cassano)<br>- grade 0, 1 (50.70%)<br>- grade 2,3 (49.30%) | None (basal) | Nasal resistance (AAR at 150 Pa) (Pa / s. cm3) | - normal (26.76%)<br>- obstruction (73.24%) | Higher sensitivity (82.7%) and specifity (82.6%) to diagnose adenoid hypertrophy with the use of ND.<br><u>ROC curve</u>: AUC=0.82 for RMN with ND, and 0.57 for basal RMN. |
| | | Habitual snorers with nasal obstruction in basal RMN | | 52 (NR) | NR ± NR (NR) | Endoscopy (Cassano)<br>- grade 0, 1 (55.77%) | Decongestant | Nasal resistance (AAR at 150 Pa) (Pa / s. cm3) | - normal (46.15%)<br>- obstruction (53.85%) | |

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|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | - grade 2,3 (44.23%) | (Xylometazoline 0.05% 2 drops/nostril) | | | |
| Cassano P *et al* 2003 | Cross-Sectional study<br>Level 3 | NA | Chronic oral respiration and/or nasal obstruction | 98 (77 M, 21 F) | 5.3 ± NR (3-14) | Endoscopy (Cassano)<br>- Grade 1: 8.2%<br>- Grade 2: 20.4%<br>- Grade 3: 64.3%<br>- Grade 4: 7.1% | None (basal) | Nasal resistance (AAR at 150 Pa) (Pa / s. $cm^3$) | Adenoid grade 1: normal resistance in 100%<br>Adenoid grade 2: normal resistance in 0%; elevated in 87.5% and high in 6.25%<br>Adenoid grade 3: normal in 14%; elevated in 64.9% and high in 21%<br>Adenoid grade 4: impossible to perform rhinomanometry | |
| Thüer U *et al* 1989 | Cross-Sectional study<br>Level 3 | NA | Malocclusion | 119 (52 M, 67 F) | NR ± NR (7.16-15.49) | Lateral cephalogram assessing size of the rhinopharynx, size of the adenoids and relative size of the adenoids. (Results NR) | None (basal) | Nasal resistance (PAR at 150 Pa) (Pa / s. $cm^3$) | 0.55 ± 0.20 | No SS association between cephalogram variables and rhinomanometry. |
| | | | | | | | Decongestant (xylometazoline) | Nasal resistance (PAR at 150 Pa) (Pa / s. $cm^3$) | 0.41 ± 0.15 | |
| Parker AJ *et al* 1989 | Cross-Sectional study<br>Level 3 | NA | OME | 40 (29 M, 11 F) | NR ± NR (4-9) | Palatal airway (mm): 4.47 ± 2.03<br>Adenoid depth (mm): 17.09 ± 2.73<br>Adenoid volume (ml): 3.57 ± 1.32 | Decongestant (6 Drops of xylometazoline 10%) | Nasal resistance (AAR at 150 Pa) (Pa / s. $cm^3$) | 0.45 ± NR (0.25-0.95) | Weak SS correlation between nasal resistance and palatal airway (rho=-0.35). No SS correlation with adenoid depth (rho= 0.20) or adenoid volume (rho=0.30) |
| Fielder CP *et al* 1985 | Quasi-experimental study | Pre-adenoidectomy | NR | 31 (14 M, 17 F) | 6.8 ± 2.4 (4-13) | Weight (gr): 1.29 ± 0.97 | None (basal) | Nasal resistance (AAR at 150 Pa) (Pa / s. $cm^3$) | 0.53 ± 0.17 | SS correlation between adenoid weight and nasal |

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|---|---|---|---|---|---|---|---|---|---|---|
| | Level 3 | Post-adenoidectomy | NR | | | | | Nasal resistance (AAR at 150 Pa) (Pa / s. $cm^3$) | 0.45 ± 0.10 | resistance (rho=0.35), and percentage of change in nasal resistance after surgery.<br>SSD between resistance before and after surgery |
| Sorensen H *et al* 1980 | Cross-Sectional study<br><br>Level 3 | Pre-adenoidectomy | NR | 24 (NR) | 8.7 ± NR (4.7-12.5) | Lateral cephalogram assessing size of the rhinopharynx, size of the adenoids and relative size. | Decongestant (Neosynephrine 0.5%) | Nasal resistance (PAR at NR reference) (Pa / s. $cm^3$) | 0.29 ± 0.15 | SS correlation between p1 (measure of the airway size in the cephalogram) and nasal resistance (rho=0.52)<br>SS correlation between t1 (size of the adenoid in the cephalogram) and nasal resistance (rho=0.58) |

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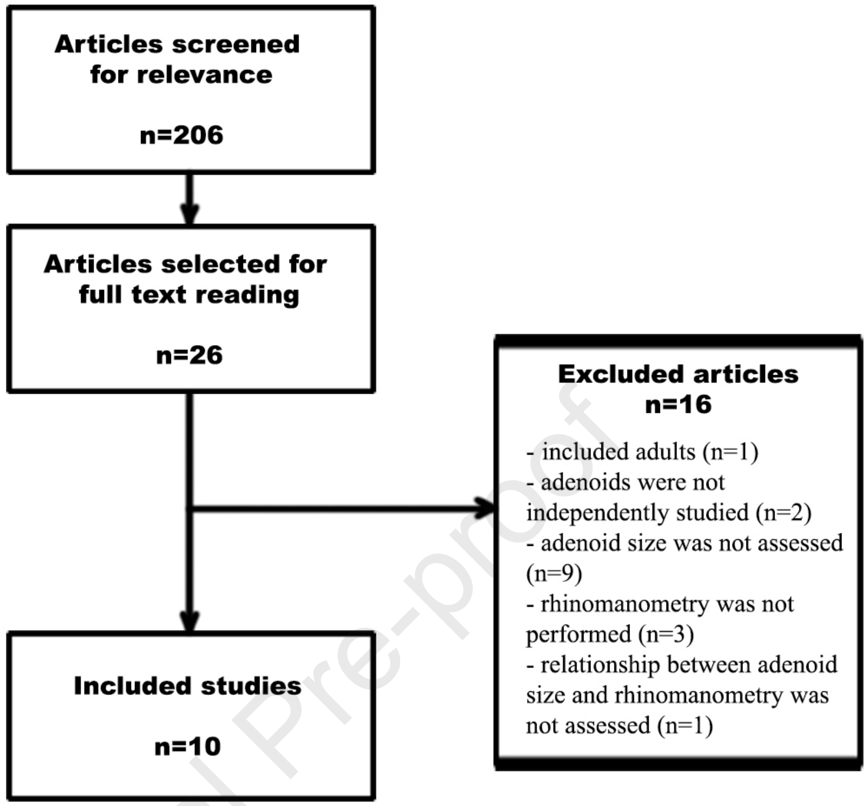
| | Sojak J et al 2018 | Rybnikar T et al 2018 | Kobayashi R *et al* 2013 | Zicari AM *et al* 2013 | Zicari AM *et al* 2012 | Cassano P *et al* 2003 | Thüer U *et al* 1989 | Parker AJ *et al* 1989 | Fielder CP *et al* 1985 | Sorensen H *et al* 1980 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1A-1 | Unclear | Unclear | Yes | Unclear | Unclear | Unclear | Unclear | Unclear | Unclear | Unclear |
| 1A-2 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 1A-3 | Yes | Yes | Unclear | Yes | Yes | Yes | Unclear | Unclear | Unclear | Unclear |
| 1A-4 | Unclear | Unclear | Yes | Yes | Yes | Unclear | Yes | Unclear | Unclear | Unclear |
| 1B | No | No | No | No | No | No | No | No | No | No |
| 2A-1 | Yes | Yes | Yes | Unclear | Unclear | Yes | Unclear | Yes | No | No |
| 2A-2 | Not applicable | Not applicable | Not applicable | Not applicable | Not applicable | Not applicable | Not applicable | Not applicable | Not applicable | Not applicable |
| 2A-3 | Yes | Yes | No | Yes | Yes | Yes | No | No | Yes | No |
| 2B-1 | No | No | No | No | No | No | No | No | Yes | No |
| 3A-1 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| 3A-2 | No | Unclear | Yes | Unclear | Unclear | Unclear | Unclear | Yes | Yes | Yes |
| 3A-3 | No | No | No | No | No | No | No | No | No | No |
| 3B-1 | No | No | No | No | No | No | No | No | No | No |


Articles screened for relevance
n=206
Articles selected for full text reading
n=26
Excluded articles
n=16
- included adults (n=1)
- adenoids were not independently studied (n=2)
- adenoid size was not assessed (n=9)
- rhinomanometry was not performed (n=3)
- relationship between adenoid size and rhinomanometry was not assessed (n=1)
Included studies
n=10