# Features of inhalant allergy on nasal endoscopy: a systematic review and meta-analysis*

Gabriel Osie[1], Kamil Wegrecki[1], Raquel Alvarado[1], Raewyn G Campbell[1,2,3], Larry Kalish[1,4,5], Janet Rimmer[1,6,7], Raymond Sacks[2,4,5], Richard J. Harvey[1,2]

[1] Rhinology and Skull Base Research Group, Applied Medical Research Centre, University of New South Wales, Sydney, Australia
[2] Faculty of Medicine, Health and Human Sciences, Macquarie University, Sydney, Australia
[3] Department of Otolaryngology Head and Neck Surgery, Royal Prince Alfred Hospital, Sydney, Australia
[4] Department of Otolaryngology, Head and Neck Surgery, Concord General Hospital, University of Sydney, Australia
[5] Faculty of Medicine, University of Sydney, Australia
[6] Woolcock Institute, University of Sydney, Australia
[7] Faculty of Medicine, Notre Dame University, Sydney, Australia

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**Background**: Nasal endoscopy is increasingly accessible to ENT surgeons. The characteristics of the allergic upper airway are not well recognised.

**Methodology**: MEDLINE (1946-2021), EMBASE (1974-2021), and the Cochrane Library were searched on 16th November 2021 to identify articles that reported endoscopic findings of patients with documented allergy who had undergone nasal endoscopy. The review followed the Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy. Meta-analysis was performed by pooling sensitivities and specificities using the hierarchical summary receiver operating characteristics model.

**Results**: A total of 4108 articles were identified, of which 15 manuscripts met the inclusion criteria. The included studies involved 4660 patients who had undergone nasal endoscopy. Middle turbinate (diffuse/polypoid) oedema (sensitivity 58.0%, specificity 84.5%), watery secretions (sensitivity 65.7%, specificity 76.5%), inferior turbinate hypertrophy (sensitivity 86.2%, specificity 32.2%), and unspecified turbinate hypertrophy (sensitivity 82.0%, specificity 42.9%) were identified as the features with the highest predictive value of inhalant allergy.

**Conclusions**: Diffuse or polypoid oedema of the middle turbinate or watery secretions seen on nasal endoscopy can be a useful adjunct in the identification and diagnosis of inhalant allergy. These clinical features should be part of the diagnostic workup for patients that includes a clinical history and surrogate markers of allergic sensitisation from the skin and serum.

**Key words**: allergy, endoscopy, respiratory hypersensitivity, turbinates

## Introduction

Patients with inhalant allergy phenotypes such as allergic rhinitis (AR) are common and often referred to otolaryngologists. Nasal endoscopy is a readily available, minimally invasive, and highly useful diagnostic tool[(1)]. It provides a significantly better view of posterior nasal structures than anterior rhinoscopy and has the benefit of being video-recordable to facilitate objective comparisons over time. A strong argument can be made for routine nasal endoscopy in the examination of patients' nose and sinuses[(2)].

Nasal examination is often used in addition to clinical history and formal allergy testing to aid the diagnosis of AR. Traditionally, nasal examination, alone, has poor sensitivity, specificity, positive predictive value, and negative predictive value compared to the allergic clinical history[(3)]. However, little consensus has existed to the key features most supportive of the allergic state. Studies have described different endoscopic features (such as inferior turbinate hypertrophy or middle turbinate head oedema) as having predictive values for the diagnosis of inhalant allergy[(4)]. Despite the abundance of primary data, no systematic

reviews or meta-analyses have been performed to determine the value of nasal endoscopy in the diagnosis of inhalant allergy.

This meta-analysis aims to assess the diagnostic accuracy of nasal endoscopy for inhalant allergy. Further, it aims to define which specific endoscopic features most support the diagnosis of the allergic state. This will assist the clinician as an additional tool to history taking and formal allergy testing, to determine if a patient's presentation is allergy driven.

## Materials and methods

A systematic review and meta-analysis was conducted to assess the diagnostic accuracy of nasal endoscopy for inhalant allergy. The review followed the Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy. The protocol was registered with the Research Registry under the unique identifying number reviewregistry991.

### Eligibility criteria

Population: Studies were eligible if they recruited patients of any age who underwent endoscopic examination of the nasal cavities. Documentation of patients' allergy status using skin prick testing (SPT) or serum specific IgE (SSIgE) was required. Patients were considered allergic if either SPT or SSIgE (or both) were positive for any antigen.
Intervention: Endoscopic examination could be performed using rigid or flexible endoscopy, with or without the use of nasal decongestant or local anesthetic. Studies were excluded if examination of the nose was not performed endoscopically.
Comparison: Studies were excluded if they did not have a non-allergic comparison group.
Outcome: Studies were excluded if they only reported endoscopic features beyond the nose and nasopharynx (such as lingual tonsil hypertrophy) or reported only the presence or absence of nasal polyps (without further specification).
Study design: Randomised controlled trials, case-controlled studies, case series, cohort studies, conference abstracts (provided adequate data) and cross-sectional studies were eligible. Review articles, commentaries, letters, and editorials, as well as animal studies were ineligible. Manuscripts not available in English were not considered.

### Information sources

A systematic electronic search was performed for relevant studies using the Ovid MEDLINE (1946-2021) and EMBASE (1974-2021) databases and the Cochrane Library until the 16th November 2021. The search strategy was designed to capture all studies with allergic subjects who underwent endoscopic assessment of the nasal cavities. Fifteen nasal examination terms (including "Endoscop*.tw" and "Nasendoscop*.tw"), twenty-nine nasal structure terms (including "Adenoid*.tw" and "Turbinat*.tw"), twenty-seven allergy terms (including "Allerg*.tw" and "Atop*.tw"), and twenty-eight outcome terms (including "Diagnos*.tw" and "Predict*.tw") were combined using the Boolean operators (AND, OR, NOT) to broaden and limit the search where appropriate. The full search strategy is available (Appendix 1). The bibliographies of included studies were manually screened for relevant articles that may have evaded detection by the search strategy. For studies where the full-text manuscript was unable to be located, authors were contacted where available.

### Study selection

The results from the electronic search were reviewed against the inclusion criteria outlined above using Rayyan (Qatar Computing Research Institute, Qatar)[5], an online review tool, and following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Appendix 2). Duplicate studies were removed automatically using the 'identify duplicates' tool on Rayyan. Study selection was performed by two authors (GO and KW) and any uncertainties were decided by consensus. As per PRISMA guidelines, duplicates were removed, and studies were screened based on title and abstract. Remaining studies were examined based on the full text. Those articles that met the inclusion criteria were included in data collection.

### Data collection process

Data extracted from individual studies were recorded in Review Manager ((RevMan)[6] (version 5.4, The Cochrane Collaboration, Denmark)[6] (performed by reviewer GO). Data fields collected included name of first author, year of publication, study design, allergy group size, comparison group size, participant age-group (children, adults, or both), participant ages, participant sexes, how allergic status was defined, use of local anesthetic or decongestant prior to endoscopy, and the presence/absence of endoscopic findings. Uncertainties were resolved by RGC, JR, and RJH. Study authors were contacted for clarification and to obtain missing information when required.

### Index tests

Due to the large number of different endoscopic features reported by the included studies, index tests were categorised into the following subgroups: turbinates, other/unspecified nasal mucosa, and adenoids. The turbinates subgroup included the features: inferior turbinate hypertrophy, posterior turbinate hypertrophy (inferior), middle turbinate (diffuse/polypoid) oedema, and unspecified turbinate hypertrophy. Posterior turbinate hypertrophy (inferior) was a name given to equivalent descriptions of the posterior inferior turbinate including 'mulberry appearance' and 'polypoid degeneration'. Middle turbinate (diffuse/polypoid) oedema was a name given to middle turbinate changes described by studies as any of hypertrophy, contact with the lateral nasal wall, or contact with the nasal

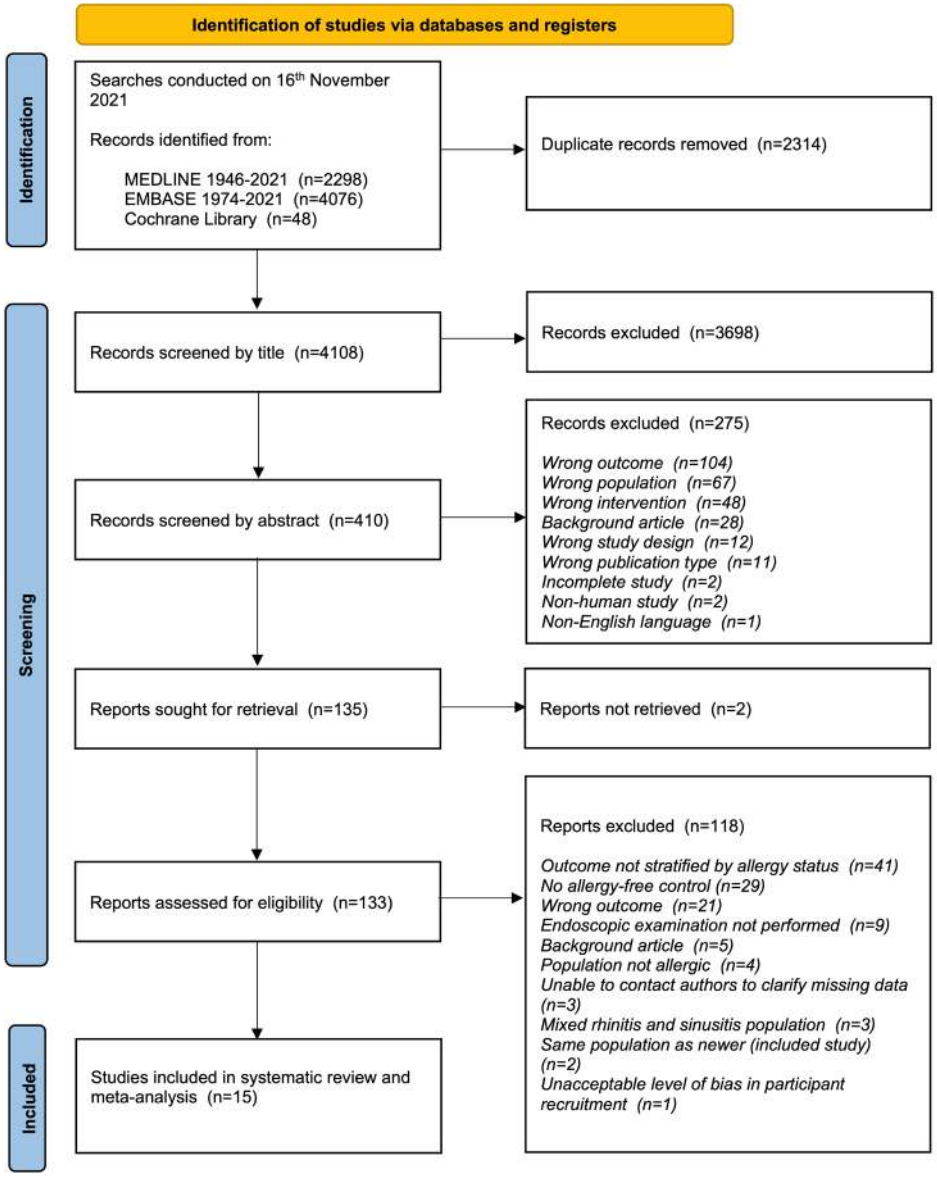



Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 flowchart highlighting the study selection process.

septum. The other/unspecified nasal mucosa subgroup included the features: oedema, pallor, purulent secretions, and watery secretions. The adenoids subgroup included the features: adenoid hypertrophy (moderate/severe) and adenoid recurrence post-adenoidectomy.

In the case where a study reported the findings of multiple examiners, a single examiner's results were reported for all findings.

### Risk of bias and applicability

Risk of bias in individual studies and concerns regarding applicability to the review question were assessed using a modified Quality Assessment of Diagnostic Accuracy Studies 2 (QUADAS-2) tool on RevMan[6] (version 5.4, The Cochrane Collaboration, Denmark)[6] (Appendix 3). Assessment of funnel plot asymmetry is not routinely performed, nor is there a sound method for detecting publication bias in meta-analyses of diagnostic test accuracy[7,8]. Heterogeneity assessment via I2 statistic is inappropriate for meta-analyses of diagnostic test accuracy[7,8].

### Statistical analysis

Sensitivity and specificity (and subsequently Youden's J statistic) were used to measure diagnostic accuracy of the index tests.

Youden's J statistic is a single statistic that describes the performance of dichotomous diagnostic tests combining both the sensitivity and specificity.
It is calculated using the formula J = Sensitivity + Specificity – 1
Data were presented in paired forest plots and in summary receiver operating characteristics (SROC) plots. Unlike receiver operating characteristics (ROC) curves which are used in primary diagnostic studies to display how the sensitivity and specificity of a single diagnostic test changes as positivity thresholds are changed, SROC curves display the meta-analysed sensitivity and specificity of several studies' diagnostic tests at a single positivity threshold in ROC space. Graphing SROC curves with sensitivity on the y-axis and 1 – specificity on the x-axis means that a perfect test's curve lies towards the top left corner, a test no better than chance sits on the middle diagonal line, and a test's curve that lies below the line is a negative predictor of the condition.
Where there were two or more studies, these were subject to meta-analysis and pooled sensitivities and specificities were derived for each index test according to the Rutter and Gatsonis Hierarchical SROC (HSROC) model[7] using the "mada" package in R (version 4.1.0, R Core Team, Austria)[9]. SROC curves were created on RevMan[6](version 5.4, The Cochrane Collaboration, Denmark)[6]. A pooled Youden's J statistic was calculated using pooled sensitivity and specificity for index tests that were meta-analysed.

## Results

### Study selection

The search strategy yielded a total of n=6422 studies. After the removal of 2314 duplicates, 4108 records were screened by title. Abstract screening was performed on 410 records. Full-text analysis was performed on 133 articles (2 full-text's were unable to be located) resulting in 15[10-24] studies being included (Figure 1).

### Characteristics of the included studies

A combined total of 4660 patients (mean age 13.4 years, female 43.6%) with documented allergy status who underwent nasal endoscopy were included in the systematic review and meta-analysis. A median of 187 participants were recruited per study (minimum 40, maximum 1322). Of the 15 included studies, 11 included a strictly pediatric population (<18 years)[10-14,16,17,19,22-24], 2 included a strictly adult population (≥18 years)[15,20], 1 included a mixed pediatric and adult population[18], and 1 did not mention if inclusion was restricted by age[21].
All articles were original with cross-sectional study designs [11-22,24], with the exception of two studies, 1 was a conference abstract with a cross-sectional design[23], and the other an original article with a self-controlled case series design[10].
Of the 15 included studies, 10 used SPT as their only reference standard[11-17,22-24], 1 used specific IgE serology as their only reference standard[20], 3 used either SPT or specific IgE serology[18,19,21], and 1 used SPT 'in season' as their reference standard (and had their same population 'out of season' as the control group as the study had a self-controlled case series design)[10].

For the nasal endoscopy procedure, 8 studies stated that local anesthetic or decongestant was applied prior to endoscopy[11-13,16,18-21], 1 stated that no local anesthetic or decongestant was used[22], and 6 did not specify if local anesthetic or decongestant was used[10,14,15,17,23,24]. It was reported that endoscopy only took place during the allergy season in 4 studies[10,15,16,21] and not specified in the remaining 11 studies[11-14,17-20,22-24].

The majority of included studies listed their exclusion criteria such as patients with anatomical deformities/systemic diseases causing airway obstruction or mucosal changes[10,12-14,16,18,24], or were using anti-inflammatory/anti-allergy medication[10-13,15,16], or who had current or recent infections in the upper respiratory tract[10-12, 15-19], or those who had any previous upper airway surgery[10, 14-16, 18], or those with suspected neoplasm[20,21].

A summary characteristics table of the included studies is available in Appendix 4.

### Risk of bias and applicability

Method of patient selection was determined to have a high risk of bias in 2 studies[17,23], unclear risk of bias in 8 studies[10,14,18-22,24], and low risk of bias in 5 studies[11-13,15,16]. Performance of the index test was determined to have a high risk of bias in 1 study(10), an unclear risk of bias in 13 studies[11-21,23,24], and a low risk of bias in 1 study[22]. The reference standard was determined to have an unclear risk of bias in 1 study[23], and a low risk of bias in 14 studies[10-22,24]. The flow and timing of studies was determined to have a high risk of bias in 2 studies[18,21], an unclear risk of bias in 1 study[19], and a low risk of bias in 12 studies[10-17,20,22-24].
Applicability concern was low for all 15 studies in all domains.
A summary of risk of bias analysis and applicability concerns is shown in Figure 2.

### Synthesis of endoscopic findings

#### *Turbinate changes*

Inferior turbinate hypertrophy was assessed in 1436 patients by 4 studies[11,13,15,16]. The inferior turbinate hypertrophy was the most sensitive but least specific with a pooled sensitivity of 86.2% (95% CI 70.1% to 94.3%), specificity 32.2% (95% CI 12.9% to 60.2%) and Youden's J statistic = 0.184 (Figure 3). Posterior turbinate hypertrophy (inferior) was assessed in 528 patients by 3 studies[15,18,21]. Pooled sensitivity was 14.3% (95% CI 9.6% to 20.8%), specificity 84.9% (95% CI 80.1% to 88.7%) and Youden's J statistic = -0.008. Middle turbinate (diffuse/polypoid) oedema was assessed in 1368 patients by 3 studies[11,13,18]. Middle

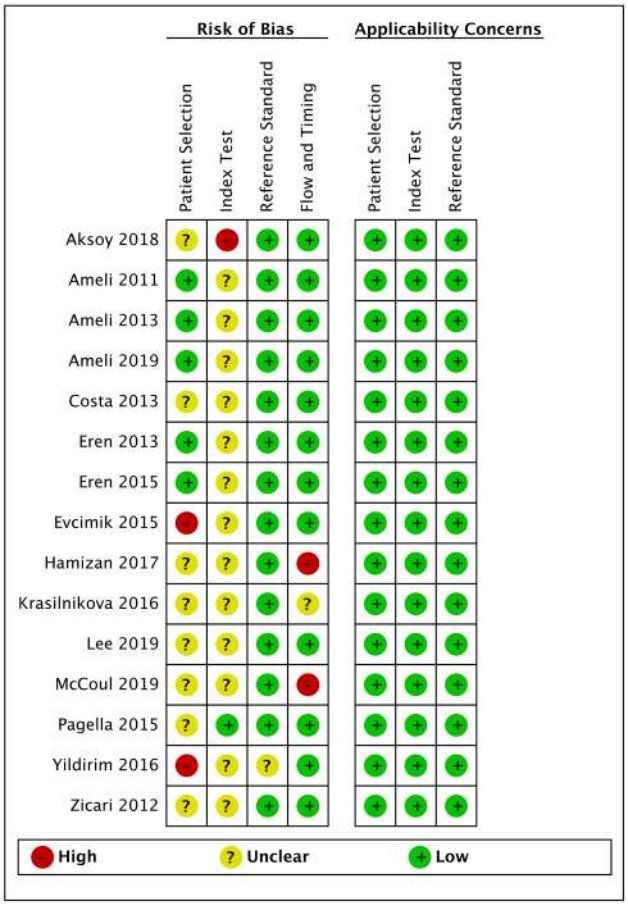



Figure 2. Risk of bias and applicability concerns summary. Assessment of each included study and classification into each domain, derived using a modified Quality Assessment of Diagnostic Accuracy Studies 2 tool on Review Manager (version 5.4, The Cochrane Collaboration, Denmark) (Appendix 3).

turbinate changes were not as sensitive for allergy but was the most specific finding with a pooled sensitivity of 58.0% (95% CI 15.0% to 91.5%), specificity 84.5% (95% CI 38.6% to 97.9%) and Youden's J statistic = 0.425. Unspecified turbinate hypertrophy was assessed in 184 patients by 2 studies[10,24]. Pooled sensitivity was 82.0% (95% CI 47.4% to 95.8%), specificity 42.9% (95% CI 31.7% to 54.8%) and Youden's J statistic = 0.249.

### Other/unspecified nasal mucosa changes

Oedema was assessed in 177 patients by 2 studies[10,15]. Pooled sensitivity was 74.3% (95% CI 18.1% to 97.4%), specificity 43.7% (95% CI 32.4% to 55.6%) and Youden's J statistic = 0.180 (Figure 4). Pallor was assessed in 1557 patients by 6 studies[10,11,13,15,16,20]. Pooled sensitivity was 57.1% (95% CI 47.0% to 66.7%), specificity 56.4% (95% CI 31.1% to 78.7%) and Youden's J statistic = 0.135. Purulent secretions were assessed in 47 patients by 1 study[20]. Sensitivity was 11.8% (95% CI 3.0% to 36.8%), specificity 90.0% (95% CI 73.2% to 96.7%) and Youden's J statistic = 0.018. Watery secretions were assessed in 120 patients by 2 studies[10,20]. Watery secretions has the best diagnostic characteristics for inhalant allergy for the mucosa with a pooled sensitivity of 65.7% (95% CI 2.4% to 99.3%), specificity 76.5% (95% CI 15.9% to 98.2%) and Youden's J statistic = 0.422.

### Adenoid changes

Adenoid hypertrophy (moderate/severe) was assessed in 3501 patients by 8 studies[12-14,16,17,19,22,24]. Pooled sensitivity was 32.7% (95% CI 20.9% to 47.0%), specificity 46.3% (95% CI 28.0% to 65.6%) and Youden's J statistic = -0.210 (Figure 5). Adenoid recurrence post-adenoidectomy was assessed in 215 patients by 1 study[23]. Sensitivity was 24.6% (95% CI 15.7% to 36.5%), specificity 88.7% (95% CI 82.5% to 92.8%) and Youden's J statistic = 0.133.

## Discussion

### Summary of evidence

Screening tools are typically used in asymptomatic patients to identify possible early stage disease. They therefore need to be highly sensitive to avoid false negative results. In contrast, diagnostic tests are typically used to establish the presence of disease in patients where disease is suspected (such as in patients with nasal complaints referred to otolaryngology clinics). Thus, diagnostic tests need to have high specificity to avoid false positives. The trade-off between specificity and sensitivity may be observed in ROC analysis (and thus SROC analysis in meta-analyses) by giving sensitivity and specificity equal weighting for optimised informedness[25].

None of the endoscopic features identified in this review provide adequate sensitivity or specificity for the diagnosis of inhalant allergy in the absence of positive clinical history and surrogate markers of allergy from skin or serum. However, among all index tests in the review, middle turbinate (diffuse/polypoid) oedema and watery secretions had the best diagnostic value for predicting inhalant allergy (pooled specificities 84.5% and 76.5% respectively, pooled Youden's J statistics 0.425 and 0.422 respectively). This was followed by unspecified turbinate hypertrophy and Inferior turbinate hypertrophy (pooled Youden's J statistics 0.249 and 0.184, respectively). The other features assessed in this review were deemed to have limited predictive value in the diagnosis of inhalant allergy.

Allergy has previously been considered a risk factor for the development of adenoid hypertrophy without significant support from the literature[26-28]. Interestingly, this review found that not only is the presence of Adenoid hypertrophy (severe/moderate) a poor predictive indicator of inhalant allergy, but it is inversely correlated with inhalant allergy (pooled Youden's J statistic -0.210). Possible explanations for this finding include decreased

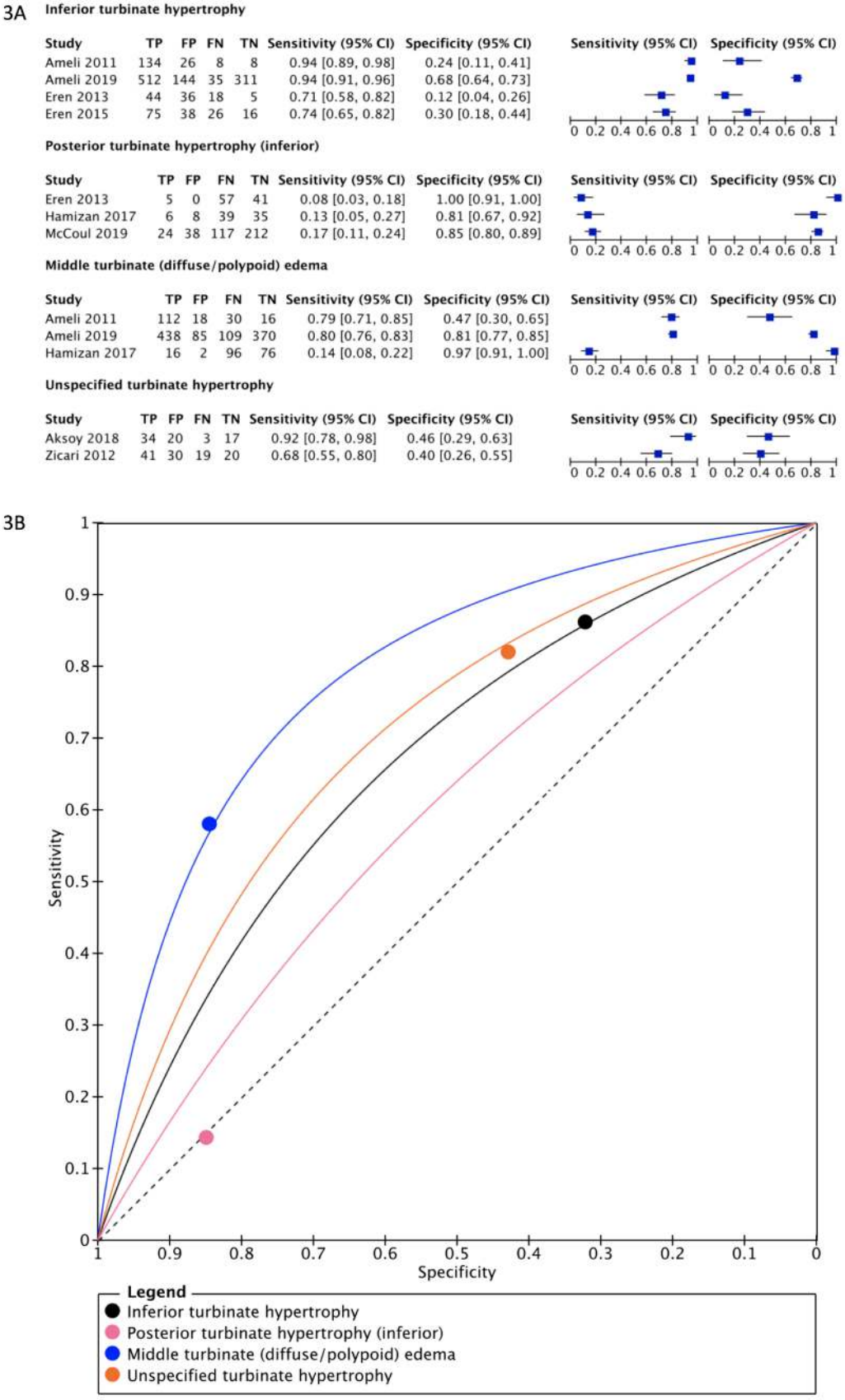



Figure 3. Diagnostic accuracy of turbinate endoscopic features for inhalant allergy. Turbinate features were identified in included studies and meta-analysed to derive forest plots (A) of sensitivity and specificity (TP = true positive, FP = false positive, FN = false negative, TN = true negative); and summary receiver operating characteristics plots (B) (Dots represent pooled sensitivity and specificity).

4A

**Edema**

| Study | TP | FP | FN | TN | Sensitivity (95% CI) | Specificity (95% CI) |
|---|---|---|---|---|---|---|
| Aksoy 2018 | 34 | 20 | 3 | 17 | 0.92 [0.78, 0.98] | 0.46 [0.29, 0.63] |
| Eren 2013 | 28 | 24 | 34 | 17 | 0.45 [0.32, 0.58] | 0.41 [0.26, 0.58] |

**Pallor**

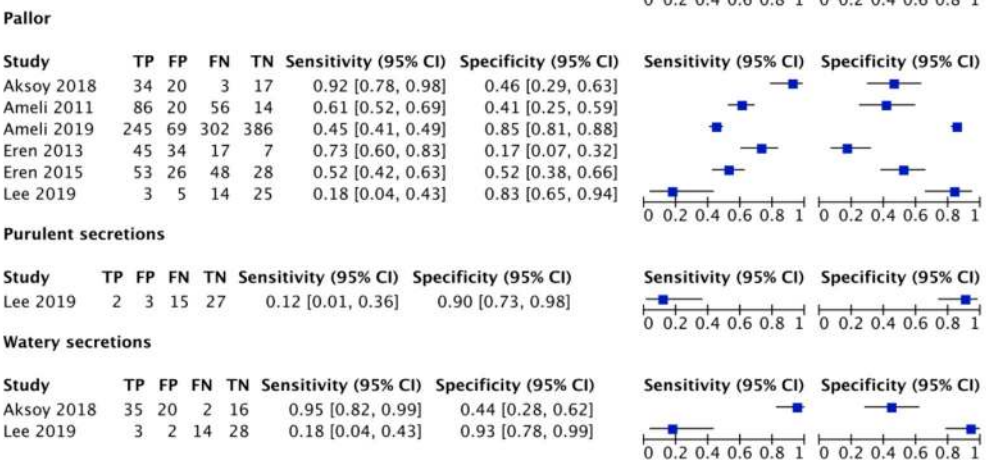
| Study | TP | FP | FN | TN | Sensitivity (95% CI) | Specificity (95% CI) |
|---|---|---|---|---|---|---|
| Aksoy 2018 | 34 | 20 | 3 | 17 | 0.92 [0.78, 0.98] | 0.46 [0.29, 0.63] |
| Ameli 2011 | 86 | 20 | 56 | 14 | 0.61 [0.52, 0.69] | 0.41 [0.25, 0.59] |
| Ameli 2019 | 245 | 69 | 302 | 386 | 0.45 [0.41, 0.49] | 0.85 [0.81, 0.88] |
| Eren 2013 | 45 | 34 | 17 | 7 | 0.73 [0.60, 0.83] | 0.17 [0.07, 0.32] |
| Eren 2015 | 53 | 26 | 48 | 28 | 0.52 [0.42, 0.63] | 0.52 [0.38, 0.66] |
| Lee 2019 | 3 | 5 | 14 | 25 | 0.18 [0.04, 0.43] | 0.83 [0.65, 0.94] |

**Purulent secretions**

| Study | TP | FP | FN | TN | Sensitivity (95% CI) | Specificity (95% CI) |
|---|---|---|---|---|---|---|
| Lee 2019 | 2 | 3 | 15 | 27 | 0.12 [0.01, 0.36] | 0.90 [0.73, 0.98] |

**Watery secretions**

| Study | TP | FP | FN | TN | Sensitivity (95% CI) | Specificity (95% CI) |
|---|---|---|---|---|---|---|
| Aksoy 2018 | 35 | 20 | 2 | 16 | 0.95 [0.82, 0.99] | 0.44 [0.28, 0.62] |
| Lee 2019 | 3 | 2 | 14 | 28 | 0.18 [0.04, 0.43] | 0.93 [0.78, 0.99] |

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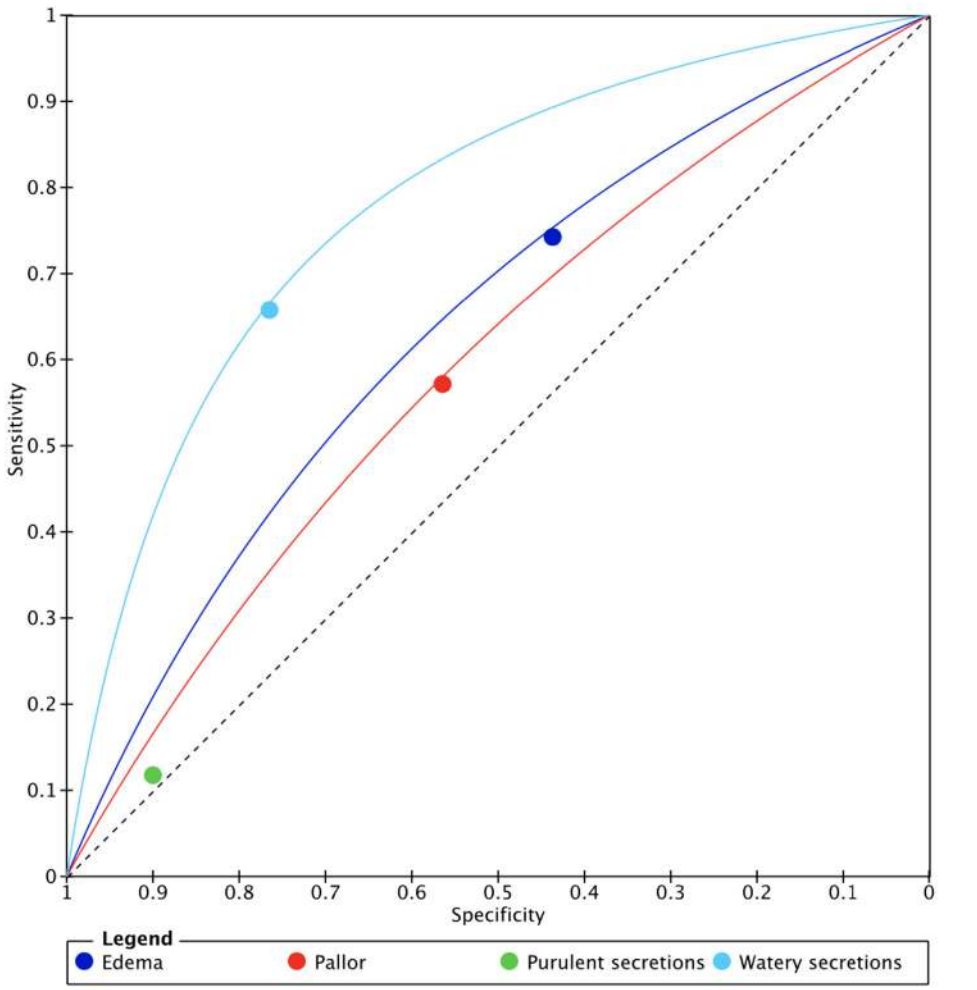


Figure 4. Diagnostic accuracy of other/unspecified nasal mucosa endoscopic features for inhalant allergy. Other/unspecified nasal mucosa features were identified in included studies and meta-analysed to derive forest plots (A) of sensitivity and specificity (TP = true positive, FP = false positive, FN = false negative, TN = true negative); and summary receiver operating characteristics plots (B) (Dots represent pooled sensitivity and specificity. Purulent secretions do not have an associated summary receiver operating characteristics curve as only one study examined this feature; hence the dot represents the individual study's sensitivity and specificity).

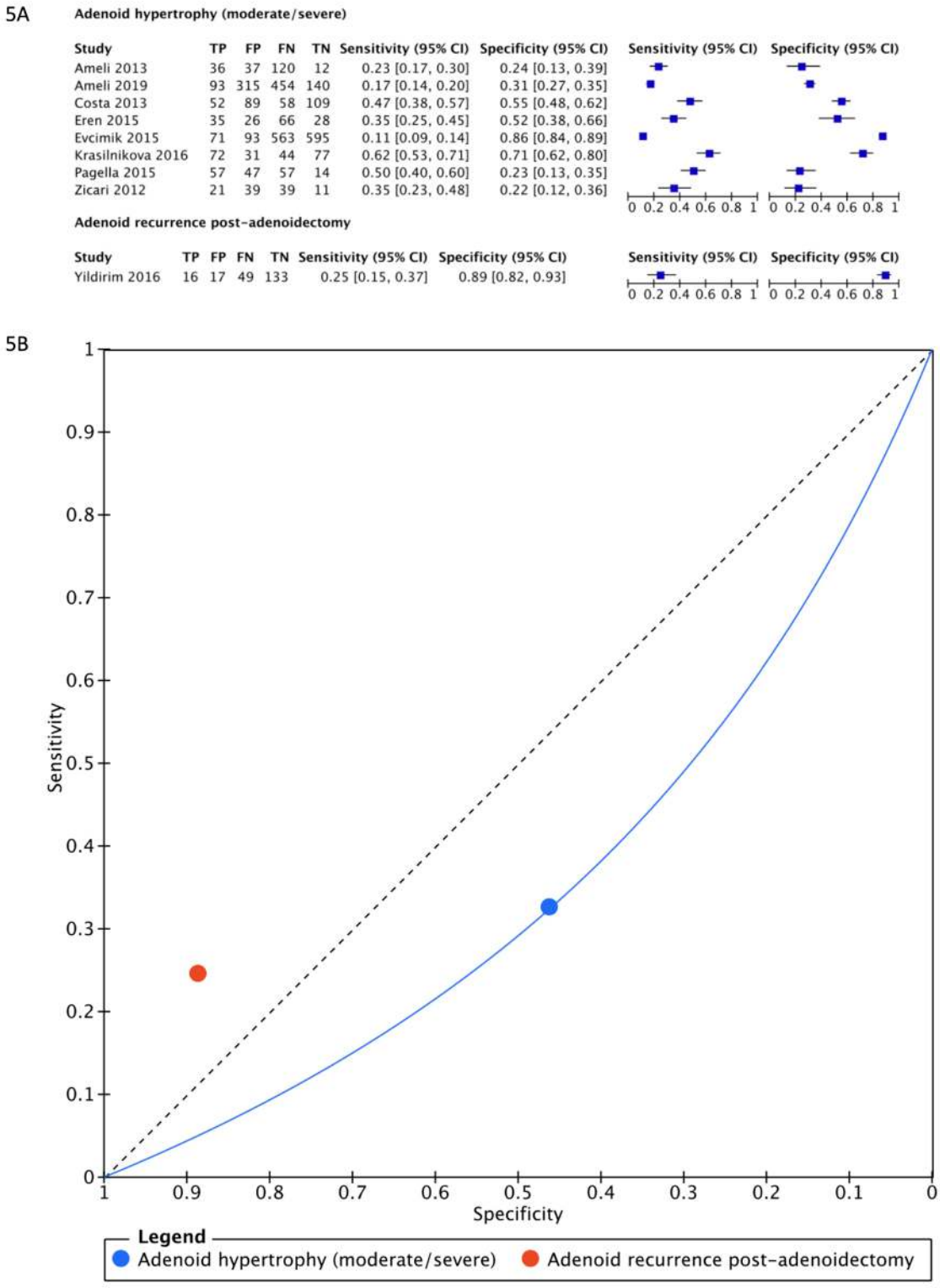


Figure 5. Diagnostic accuracy of adenoid endoscopic features for inhalant allergy. Adenoid features were identified in included studies and meta-analysed to derive forest plots (A) of sensitivity and specificity (TP = true positive, FP = false positive, FN = false negative, TN = true negative); and summary receiver operating characteristics plots (B) (Dots represent pooled sensitivity and specificity. Adenoid recurrence post-adenoidectomy does not have an associated summary receiver operating characteristics curve as only one study examined this feature; hence the dot represents the individual study's sensitivity and specificity).

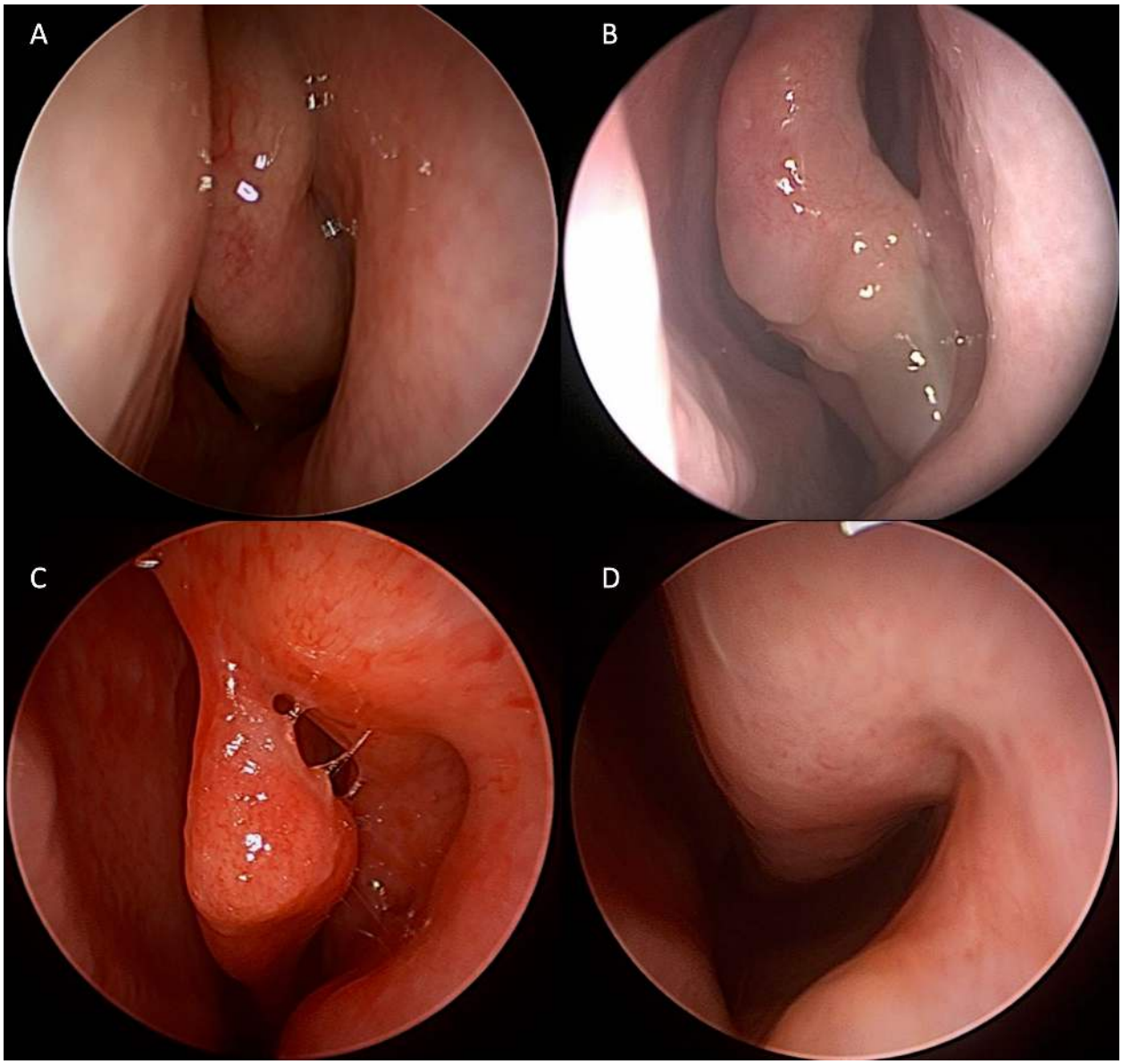


Figure 6. Nasal endoscopic representative images of features most predictive of inhalant allergy. Images were obtained using a 0-degree rigid endoscope after the use of a nasal decongestant. A: Middle turbinate diffuse oedema, B: Middle turbinate polypoid oedema, C: Watery secretions, D: Inferior turbinate hypertrophy.

adenoidal stimulation due to nasal obstruction, in the setting of allergy, or nasal symptoms a result of large adenoid and not allergic drive[29]. Hence the identification of Adenoid hypertrophy (moderate/severe) on nasal endoscopy should lower a clinician's suspicion of inhalant allergy. This was the only feature identified to have an inverse correlation with inhalant allergy.

**Limitations**

Although the assessing the diagnostic value of a combination of summed variables would have been informative for the review, unfortunately the raw data to calculate summed variables was not available in the literature for any of the included studies. There would be value in a study assessing the diagnostic accuracy of the presence of middle turbinate oedema and inferior turbinate hypertrophy and watery secretions. This could further be enhanced by including symptom variables, as well as demographic features such as age group and sex. Such analysis would require individual patient data sets and while multivariate analysis of individual patient characteristics is possible in well-designed individual studies, it is not possible in a meta-analysis of pooled population data.

Patients were considered allergic if either SPT or SSIgE (or both) were positive. Combining studies with different reference standards could be a source of differential reference bias (a type of verification bias). However, this is unlikely to cause significant

bias as both SPT and SSIgE are considered as gold standards and are roughly equivalent[30-33].

Visual assessment of study results in forest plots suggests a degree of between-study heterogeneity. By comparing the forest plots with the exclusion criteria reported by studies (Appendix 4), it was determined that structural abnormalities in patients' nasal cavities were unlikely to significantly contribute to the heterogeneity observed. Where study results differ but confidence intervals overlap, this is likely explained by sampling variation[8]. In the cases where confidence intervals do not overlap, heterogeneity is likely caused by threshold variation between studies[8] discussed below. Formal heterogeneity analysis is unlikely to produce meaningful results in subgroups with only one or two studies[8] and thus was not performed.

During the data extraction process, it was observed that clinicians had different ways of classifying synonymous and/or similar endoscopic features. Among the included studies, adenoid hypertrophy was graded using 4 separate classification systems: Parikh's criteria (an objective grade based on the relationship of the adenoids to adjacent anatomical structures)[12, 13, 16, 22], Saedi criteria (an objective grade based on the proportion of choanae obstructed by the adenoids)[17, 19], Cassano grades (a subjective grade based on how far inferiorly the adenoids obstruct the choanae)[24], and an unnamed subjective scale rating the obstruction of the cavum by adenoids in at least one nostril >70%[14]. Several other endoscopic grading systems for adenoid hypertrophy were found in the literature but weren't used by the included studies. Whilst it was attempted to classify the presence and absence of adenoid hypertrophy as pathological vs non-pathological (as described in the Methods), it is possible that a pathological grade within one classification system would be reported as a non-pathological grade in an alternative system, leading to a misclassification bias.

Some endoscopic findings do not have a widely accepted (or well-defined) way of being reported. This can lead to endoscopic features being incorrectly reported as present or absent. For example, 'watery secretions' was an umbrella term used by this review to describe 'rhinorrhoea'[10] and 'watery discharge'[20]. Anecdotally, watery discharge seen in patients with inhalant allergy has been referred to as having a spiderwebbed appearance. Whilst clinicians should easily be able to differentiate between a nose without any discharge and a nose with significant watery discharge, there is no consensus on the volume or characteristics of the discharge for the clinician to determine whether the presence of discharge warrants reporting. Turbinate hypertrophy is another feature identified as having poorly described definition. Within this review, inferior turbinate hypertrophy was defined as (inferior) turbinate contact with the lateral wall by 3 studies[11, 13, 16] and was not explicitly defined in 1 study[15]. Turbinate hypertrophy was described in 2 studies[10, 24] without specifying which turbinates were examined. It is likely that authors of these studies were describing inferior turbinate hypertrophy as they are encountered first in nasal endoscopy, however the groups were kept separate for statical rigor. This assumption is supported by the similar location of summary points shown in Figure 3B. Within this review, middle turbinate (diffuse/polypoid) oedema was defined as (middle) turbinate contact with the lateral wall by 2 studies[11,13]. Hamizan et al. defined diffuse and polypoid oedema of the middle turbinate separately, "Diffuse oedema was defined as a translucent, jelly-like mucosal surface occupying the entire leading edge of the middle turbinate mucosa without any intervening normal mucosa. Polypoid oedema was defined as a grapelike, translucent protrusion hanging beyond the leading edge of the middle turbinate mucosa"[18]. Examples of the some of the more predictive features of allergy identified in this review are shown in Figure 6.

Several studies have reported poor inter-rater reliability for various endoscopic findings. The inter-rater reliability of inferior turbinate hypertrophy has been reported in the literature as fair[15] to substantial[34], whereas posterior turbinate hypertrophy (inferior) has been reported as poor[34,35] to moderate[15]. The inter-rater reliability of middle turbinate hypertrophy was found to be substantial by one study[34]. The inter-rater reliability of grading adenoid hypertrophy by endoscopy has been previously discussed in the literature with mixed reports on its reliability[36-39] ranging from fair[35] to substantial[34]. Another consideration is the type of endoscope used (flexible vs rigid). Rigid endoscopy may provide better image quality than flexible. However, this is unlikely to affect assessment of adenoid hypertrophy[40]. Having universally standardised definitions, descriptions, and grading systems for features of nasal endoscopy would enable more accurate reporting of findings and improve inter-rater reliability.

The analysis includes overlapping paediatric and adult populations. Ideally studies would have been separated by age category; however, due the small number of studies reporting each endoscopic feature, splitting the studies further would be insufficient to generate meaningful outcomes. It should be noted that all studies reporting adenoid hypertrophy, a predominantly paediatric condition, incorporated only paediatric participants.

Finally, the use of local anesthetic or decongestant prior to endoscopy was a possible confounder. Using these agents prior to endoscopy may lead to clinicians not identifying features such as oedema or inferior turbinate hypertrophy. However, not using these agents might lead to poorer visualisation of the nasal cavities and structures[41] and be more painful for the patient.

## Conclusion

Diffuse or polypoid oedema of the middle turbinate or watery secretions seen on nasal endoscopy can be a useful adjunct in the identification and diagnosis of inhalant allergy. Identifying these clinical features would be useful in the diagnostic workup for potentially allergic patients in addition to taking a clinical history and formal allergy testing via surrogate markers of allergic sensitisation from the skin and serum.

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## Authorship contribution

GO: Development of search strategy, study selection, data extraction, statistical analysis, risk of bias assessment, writing of manuscript, editing, accepting final version of manuscript. KW: Development of search strategy, study selection, editing, accepting final version of manuscript. RA, RGC, LK, JR, RS: Formulation of research question, development of search strategy, data extraction, editing, accepting final version of manuscript. RJH: Formulation of research question, development of search strategy, data extraction, statistical analysis, editing, accepting final version of manuscript.

*Orcid IDs for authors*

Richard J Harvey 0000-0002-6942-8975
Gabriel Osie 0000-0002-7601-1369
Kamil Wegrecki 0000-0003-2305-0126
Raymond Sacks 0000-0002-9260-5175
Raquel Alvarado 0000-0001-7250-2200
No Orcid ID supplied for remaining authors.

## Conflict of interest

Richard J Harvey is consultant/advisory board with Medtronic, Novartis, GSK and Meda pharmaceuticals. Research grant funding received from Glaxo-Smith-Kline. He has been on the speakers' bureau for Glaxo-Smith-Kline, Astra-zeneca, Meda Pharmaceuticals and Seqirus. Janet Rimmer has honoraria with Sanofi Aventis, Novartis, Mundipharma, BioCSL, Stallergenes. Raymond Sacks is a consultant for Medtronic and is in the speaker bureau for Meda Pharmaceuticals. Larry Kalish is on the speakers' bureau for Care Pharmaceuticals, Mylan and Seqirus Pharmaceuticals. The remaining authors have no financial disclosures or conflicts of interest.

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Gabriel Osie
67 Burton Street
Darlinghurst NSW 2010
Australia

Tel: +612 9360 4811
Fax: +612 9360 1999
E-mail: gabriel.osie@hotmail.com

**This manuscript contains online supplementary material**

## SUPPLEMENTARY MATERIAL

Appendix 1. Search strategy terms used in MEDLINE (1946–2021) and EMBASE (1974–2021) databases. Search performed on 16 November 2021.

| Nasal examination terms | Nasal structure terms | Allergy terms | Outcome terms |
|---|---|---|---|
| 1. Endonasal.tw | 17. Adenoid*.tw | 47. Aeroallerg*.tw | 75. Appear*.tw |
| 2. Endoscop*.tw | 18. Atrium*.tw | 48. Airbo?rn?.tw | 76. Associat*.tw |
| 3. Fib??optic.tw | 19. Bulla*.tw | 49. Allerg*.tw | 77. Characteris*.tw |
| 4. Intranasal.tw | 20. Cartilag*.tw | 50. Animal epithelium.tw | 78. Correlat*.tw |
| 5. nasal exam*.tw | 21. Choana*.tw | 51. Atop*.tw | 79. Define*.tw |
| 6. nasal assessment.tw | 22. Cobbleston*.tw | 52. CCAD.tw | 80. Denot*.tw |
| 7. Nose ADJ3 exam*.tw | 23. Concha*.tw | 53. Central compartment atopic disease.tw | 81. Diagnos*.tw |
| 8. Nasendoscop*.tw | 24. Ethmoid*.tw | 54. Dander*.tw | 82. Distinguish*.tw |
| 9. Nasolaryngoscop*.tw | 25. Frontonasal*.tw | 55. Dust*.tw | 83. Featur*.tw |
| 10. Nasopharyngolaryngoscop*.tw | 26. Hypertroph*.tw | 56. Eosinophil*.tw | 84. Finding*.tw |
| 11. Nasopharyngoscop*.tw | 27. Limen*.tw | 57. Feather*.tw | 85. Hallmark*.tw |
| 12. "RGB analysis".tw | 28. Maxilla*.tw | 58. Fung*.tw | 86. Indicat*.tw |
| 13. Red Green Blue analysis.tw | 29. Meatal*.tw or Meatus*.tw | 59. Fur.tw, | 87. Pathogno*.tw |
| 14. Rhinolaryngoscop*.tw | 30. Mucosa*.tw | 60. Grass.tw | 88. Predict*.tw |
| 15. Rhinoscop*.tw | 31. Nare*.tw | 61. Hay fever OR hayfever.tw | 89. Prognos*.tw |
| 16. 1-15 OR | 32. Nasal*.tw | 62. Histamine.tw | 90. Suggesti*.tw |
| | 33. Naso*.tw | 63. Hypersensitiv*.tw | 91. Typical*.tw |
| | 34. Nose*.tw | 64. IgE.tw | 92. reliab*.tw |
| | 35. Nostril* | 65. Immunoglobulin ADJ1 E.tw | 93. Consisten*.tw |
| | 36. Polyp*.tw | 66. Inhalant*.tw | 94. Depend*.tw |
| | 37. Semilunar*.tw | 67. Mo?ld.tw | 95. Confiden*.tw |
| | 38. Septal*.tw OR septum*.tw | 68. Perennial rhinitis.tw | 96. Accura*.tw |
| | 39. Sinus*.tw | 69. poll?nosis.tw | 97. Trustw*.tw |
| | 40. Spheno*.tw | 70. Pollen.tw | 98. Reprod*.tw |
| | 41. Tonsil*.tw | 71. Seasonal rhinitis.tw | 99. Precis*.tw |
| | 42. Turbinat*.tw | 72. Spore* OR Sporo*.tw | 100. Correc*.tw |
| | 43. Uncinate*.tw | 73. Weed*.tw | 101. Exact*.tw |
| | 44. Vestibul*.tw | 74. 47-73 OR | 102. Valid*.tw |
| | 45. Vibriss*.tw | | 103. 75-102 OR |
| | 46. 17-45 OR | | |

104. 16 AND 46 AND 74 AND 103
105. Limit 104 to (human and English language)
106. (colon* or colorectal* or rect* or anal* or abdom* or f?ecal* or colitis or enteritis or gastr* or stomach* or duoden* or jeju* or ileal or ileum or intestin* or bowel* or esoph* or oesoph* or pancrea* or gallbladder* or cystic fibrosis or cancer or appendix).ti.
107. 105 NOT 106

Appendix 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 Checklist.

| Section and Topic | Item # | Checklist item | Pages where items are reported |
|---|---|---|---|
| **TITLE** | | | |
| Title | 1 | Identify the report as a systematic review. | 1 |
| **ABSTRACT** | | | |
| Abstract | 2 | See the PRISMA 2020 for Abstracts checklist. | 1 |
| **INTRODUCTION** | | | |
| Rationale | 3 | Describe the rationale for the review in the context of existing knowledge. | 1,2 |
| Objectives | 4 | Provide an explicit statement of the objective(s) or question(s) the review addresses. | 2 |
| **METHODS** | | | |
| Eligibility criteria | 5 | Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses. | 2 |
| Information sources | 6 | Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted. | 2 |
| Search strategy | 7 | Present the full search strategies for all databases, registers and websites, including any filters and limits used. | 2,13 |

| Section and Topic | Item # | Checklist item | Pages where items are reported |
|---|---|---|---|
| Selection process | 8 | Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process. | 2 |
| Data collection process | 9 | Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process. | 2 |
| Data items | 10a | List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect. | 2,3 |
| | 10b | List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information. | 2,3 |
| Study risk of bias assessment | 11 | Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process. | 3,15,16 |
| Effect measures | 12 | Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results. | 3,4 |
| Synthesis methods | 13a | Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)). | N/A |
| | 13b | Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions. | 4 |
| | 13c | Describe any methods used to tabulate or visually display results of individual studies and syntheses. | N/A |
| | 13d | Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used. | 4 |
| | 13e | Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression). | 3 |
| | 13f | Describe any sensitivity analyses conducted to assess robustness of the synthesized results. | N/A |
| Reporting bias assessment | 14 | Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases). | N/A |
| Certainty assessment | 15 | Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome. | N/A |
| **RESULTS** | | | |
| Study selection | 16a | Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram. | 3,4 |
| | 16b | Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded. | N/A |
| Study characteristics | 17 | Cite each included study and present its characteristics. | 4,11,12,16, 17,18 |
| Risk of bias in studies | 18 | Present assessments of risk of bias for each included study. | 4,5 |
| Results of individual studies | 19 | For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots. | N/A |
| Results of syntheses | 20a | For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies. | 4,5 |
| | 20b | Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect. | 4,5,6,7,8 |
| | 20c | Present results of all investigations of possible causes of heterogeneity among study results. | 9,10 |
| | 20d | Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results. | N/A |
| Reporting biases | 21 | Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed. | N/A |

| Section and Topic | Item # | Checklist item | Pages where items are reported |
|---|---|---|---|
| Certainty of evidence | 22 | Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed. | N/A |
| **DISCUSSION** | | | |
| Discussion | 23a | Provide a general interpretation of the results in the context of other evidence. | 5 |
| | 23b | Discuss any limitations of the evidence included in the review. | 9,10 |
| | 23c | Discuss any limitations of the review processes used. | 9,10 |
| | 23d | Discuss implications of the results for practice, policy, and future research. | 9,10 |
| **OTHER INFORMATION** | | | |
| Registration and protocol | 24a | Provide registration information for the review, including register name and registration number, or state that the review was not registered. | 2 |
| | 24b | Indicate where the review protocol can be accessed, or state that a protocol was not prepared. | N/A |
| | 24c | Describe and explain any amendments to information provided at registration or in the protocol. | N/A |
| Support | 25 | Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review. | 11 |
| Competing interests | 26 | Declare any competing interests of review authors. | 11 |
| Availability of data, code and other materials | 27 | Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review. | N/A |

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

Appendix 3. Modified Quality Assessment of Diagnostic Accuracy Studies 2 questions for risk of bias assessment.

| **Participant selection** | |
|---|---|
| 1 – Was a consecutive or random sample of patients enrolled? | NO – It was obvious that another method of participant selection was used<br>YES – Study stated that all participants within a time frame were consecutively included or that a random selection was done<br>UNCLEAR – selection procedure unclear or not reported |
| 2 – Was a case-control design avoided? | NO – If the non-allergic patients were selected by other means (e.g. healthy volunteers)<br>YES – If the allergic and non-allergic patients were selected from the same overall group<br>UNCLEAR – selection procedure unclear or not reported |
| 3 – Did the study avoid inappropriate exclusions?<br>(This was addressed case-by-case) | NO – If there were many excluded patients for inappropriate reasons<br>YES – If most excluded patients were excluded for appropriate reasons<br>UNCLEAR – If the exclusion criteria were not reported |
| 4 – Did the study avoid only including patients on the basis of them having a previously diagnosed condition that would likely alter endoscopic findings regardless of allergy status (e.g. CRS) | NO – If the population of included patients were not recruited because they all had an underlying previously diagnosed rhinological condition<br>YES – If the answer to this question was not NO |
| 5 – Were patients still included if they were being medicated with anti-allergy or anti-inflammatory drugs, or were post-operative at time of endoscopy | NO – If the study excluded patients that were being medicated or were post-operative at the time of endoscopy<br>YES – If the study recorded, but did not exclude patients who were currently medicated or were post-operative at the time of endoscopy<br>UNCLEAR – If the study did not mention if these patients were being medicated or were post-operative at the time of endoscopy |
| Could the selection of patients have introduced bias? | Low risk – All 5 questions were answered NO<br>High risk – Any of the 5 questions were answered YES<br>Unclear risk – All other situations |
| Are there concerns that the included patients and setting do not match the review question? | Low concern – If the answer to question 4 was NO<br>High concern – If the answer to question 4 was YES<br>Unclear concern – If the study lacked a description of their patient selection process |

| | |
|---|---|
| **Index test** | |
| 1 – Were the investigators blinded to the patients' allergy statuses at the time of endoscopy? | YES – If the study explicitly stated that the investigators were blinded to the patients' allergy statuses<br>NO – If it was obvious that the investigators were not blinded to the patients' allergy statuses<br>UNCLEAR – If it wasn't stated or was unclear if the investigators knew the patients' allergy statuses |
| 2 – Were the nasal cavities examined under endoscopy without the use of local anesthetic or decongestant? | YES – if the study explicitly stated that nasal cavities were endoscopically examined without the use of local anesthetic or decongestant<br>NO – If the study explicitly stated that nasal cavities were prepared with local anesthetic or decongestant prior to endoscopy<br>UNCLEAR – If the study did not mention whether or not local anesthetic or decongestant was used |
| Could the conduct or interpretation of the index test have introduced bias? | Low risk – YES both questions<br>High risk – NO to question 1<br>Unclear risk – All other situations |
| Are there concerns that the index test, its conduct, or interpretation differ from the review question? | Low concern – All studies are likely to be rated as having a low concern |
| **Reference standard** | |
| 1 – Was the method of determining allergy status clearly described? | YES – Clearly described method of determining of allergy status<br>NO – If the answer to this question was not YES |
| 2 – Was allergy status known prior to index test results? | YES – If it was clear that endoscopy was performed after the determination of allergy status<br>NO – If it was clear that allergy status was determined after endoscopy was performed and that investigators weren't blinded to their endoscopy results<br>UNCLEAR – If it was unclear whether allergy status was determined before or after endoscopy was performed |
| Could the reference standard, its conduct, or its interpretation have introduced bias? | Low risk – YES to both questions<br>High risk – NO to either question<br>Unclear risk – All other situations |
| Are there concerns that the target condition as defined by the reference standard does not match the question?<br>(This was addressed on a case-by-case basis) | Low concern – If the method of defining allergy status was deemed adequate by the reviewers<br>High concern – If the method of defining allergy status was deemed inadequate by the reviewers |
| **Index test** | |
| 1 – Did all patients receive the same test for determination of allergy | YES – The study clearly mentioned that all patients had the same type of test in the determination of their allergy status<br>NO – The study mentioned that more than one possible test was used in the determination of allergy status<br>UNCLEAR – The study did not state how allergy status was determined |
| Could the patient flow have introduced bias? | Low risk – YES to question 1<br>High risk – NO to question 1<br>Unclear risk – UNCLEAR to question 1 |

Appendix 4. Table of characteristics of studies included in the systematic review and meta-analysis.

A.

| First author: Title | Year | Study design | Allergy group size (n) | Comparison group size (n) | Participant age group | Mean age (years) | Gender (% female) |
|---|---|---|---|---|---|---|---|
| **Aksoy**: Evaluation of olfactory function in children with seasonal allergic rhinitis and its correlation with acoustic rhinometry | 2018 | Self controlled case series | 40 | 0 | Children | 13 | 37. 8 |
| **Ameli**: Nasal endoscopy in children with suspected allergic rhinitis | 2011 | Cross-sectional | 142 | 34 | Children | 7.5 | 43. 8 |
| **Ameli**: Adenoidal hypertrophy and allergic rhinitis: is there an inverse relationship? | 2013 | Cross-sectional | 156 | 49 | Children | 6.7 | Not stated |
| **Ameli**: Can an otorhinolaryngological visit induce the suspect of allergic rhinitis in children? | 2019 | Cross-sectional | 547 | 455 | Children | 5.8 | 45. 1 |

| First author: Title | Year | Study design | Allergy group size (n) | Comparison group size (n) | Participant age group | Mean age (years) | Gender (% female) |
|---|---|---|---|---|---|---|---|
| **Costa**: Atopy and adenotonsillar hypertrophy in mouth breathers from a reference center | 2013 | Cross-sectional | 110 | 198 | Children | 7.3 | 40. 6 |
| **Eren**: Diagnosis of allergic rhinitis: inter-rater reliability and predictive value of nasal endoscopic examination: a prospective observational study | 2013 | Cross-sectional | 62 | 41 | Adults | 33. 8 | 66. 7 |
| **Eren**: Chicken or the egg: the dilemma of allergic rhinitis versus adenoid hypertrophy* | 2015 | Cross-sectional | 101 | 54 | Children | 8.7 | 29. 7 |
| **Evcimik**: Adenoid hypertrophy in children with allergic disease and influential factors. | 2015 | Cross-sectional | 634 | 688 | Children | 5.8 | 42. 1 |
| **Hamizan**: Middle turbinate edema as a diagnostic marker of inhalant allergy | 2017 | Cross-sectional | 106 | 81 | Both | 39. 7 | 42. 2 |
| **Krasilnikova**: Capabilities of Nasal Videoendoscopy in Diagnostics of Pharyngeal Tonsil Condition in Children with Bronchial Asthma | 2016 | Cross-sectional | 116 | 108 | Children | 9.7 | 25 |
| **Lee**: Association of Sinonasal Factors With Chronic Laryngitis in Korean Adults | 2019 | Cross-sectional | 17 | 30 | Adults | 50. 1 | 44. 7 |
| **McCoul**: Posterior Inferior Turbinate Hypertrophy (PITH) | 2019 | Cross-sectional | 141 | 250 | Unspecified | 53. 1 | 60. 1 |
| **Pagella**: Adenoids and clinical symptoms: Epidemiology of a cohort of 795 pediatric patients | 2015 | Cross-sectional | 114 | 61 | Children | 5.9 | 42. 1 |
| **Yildirim**: Management of Adenoid Hypertrophy in Allergic Children, How Effective Is Surgery? | 2016 | Cross-sectional (conference abstract) | 65 | 150 | Children | Not stated | Not stated |
| **Zicari**: Habitual snoring and atopic state: correlations with respiratory function and teeth occlusion | 2012 | Cross-sectional | 60 | 50 | Children | 8.2 | 40 |

Appendix 4. Table of characteristics of studies included in the systematic review and meta-analysis.

B.

| First author | Year | How allergy was defined | Endoscopy only performed in allergy season | How comparison was defined | Anaesthetic or decongestant used prior to endoscopy | Endoscopic features reported | Exclusion criteria |
|---|---|---|---|---|---|---|---|
| Aksoy | 2018 | Positive SPT - In season | Yes* | *Patient was own control out of season | Unspecified | Edema<br>Pallor<br>Unspecified turbinate hypertrophy<br>Watery secretions | Active/recent upper respiratory infection<br>Anatomical deformity/systemic disease causing airway obstruction or mucosal changes<br>Current anti-inflammatory/anti-allergy medication<br>Previous upper airway surgery Smoking |
| Ameli | 2011 | Positive SPT | No | Negative SPT | Yes | Inferior turbinate hypertrophy<br>Middle turbinate (diffuse/polypoid) edema Pallor | Active/recent upper respiratory infection<br>Chronic rhinosinusitis<br>Current anti-inflammatory/anti-allergy medication |
| Ameli | 2013 | Positive SPT | No | Negative SPT | Yes | Adenoid hypertrophy (moderate/severe) | Active/recent upper respiratory infection<br>Anatomical deformity/systemic disease causing airway obstruction or mucosal changes<br>Current anti-inflammatory/anti-allergy medication |

| First author | Year | How allergy was defined | Endoscopy only performed in allergy season | How comparison was defined | Anaesthetic or decongestant used prior to endoscopy | Endoscopic features reported | Exclusion criteria |
|---|---|---|---|---|---|---|---|
| Ameli | 2019 | Positive SPT | No | Negative SPT | Yes | Adenoid hypertrophy (moderate/severe)<br>Inferior turbinate hypertrophy<br>Middle turbinate (diffuse/polypoid) edema Pallor | Anatomical deformity/systemic disease causing airway obstruction or mucosal changes<br>Current anti-inflammatory/anti-allergy medication |
| Costa | 2013 | Positive SPT | No | Negative SPT | Unspecified | Adenoid hypertrophy (moderate/severe) | Anatomical deformity/systemic disease causing airway obstruction or mucosal changes<br>Previous upper airway surgery |
| Eren | 2013 | Positive SPT | Yes | Negative SPT | Unspecified | Edema<br>Inferior turbinate hypertrophy<br>Pallor<br>Posterior turbinate hypertrophy (inferior) | Active/recent upper respiratory infection<br>Current anti-inflammatory/anti-allergy medication<br>Previous upper airway surgery |
| Eren | 2015 | Positive SPT | Yes | Negative SPT | Yes | Adenoid hypertrophy (moderate/severe)<br>Inferior turbinate hypertrophy<br>Pallor | Active/recent upper respiratory infection<br>Anatomical deformity/systemic disease causing airway obstruction or mucosal changes<br>Current anti-inflammatory/anti-allergy medication<br>Previous upper airway surgery |
| Evcimik | 2015 | Positive SPT | No | Negative SPT | Unspecified | Adenoid hypertrophy (moderate/severe) | None |
| Hamizan | 2017 | Either positive SPT or specific IgE serology | No | Negative SPT or serology | Yes | Middle turbinate (diffuse/polypoid) edema Posterior turbinate hypertrophy (inferior) | Anatomical deformity/systemic disease causing airway obstruction or mucosal changes<br>Chronic rhinosinusitis<br>Previous upper airway surgery |
| Krasilnikova | 2016 | Either positive SPT or specific IgE serology | No | Negative SPT or serology | Yes | Adenoid hypertrophy (moderate/severe) | Active/recent upper respiratory infection |
| Lee | 2019 | Positive specific IgE serology | No | Negative specific IgE serology | Yes | Pallor<br>Purulent secretions<br>Watery secretions | Suspected sinonasal neoplasm |
| McCoul | 2019 | Either positive SPT or specific IgE serology | Yes | Negative SPT or serology | Yes | Posterior turbinate hypertrophy (inferior) | Suspected sinonasal neoplasm |
| Pagella | 2015 | Positive SPT | No | Negative SPT | No | Adenoid hypertrophy (moderate/severe) | None |
| Yildirim | 2016 | Positive SPT | No | Negative SPT | Unspecified | Adenoid recurrence post- adenoidectomy | Residual adenoid tissue immediately post- adenoidectomy |
| Zicari | 2012 | Positive SPT | No | Negative SPT | Unspecified | Adenoid hypertrophy (moderate/severe)<br>Unspecified turbinate hypertrophy | Anatomical deformity/systemic disease causing airway obstruction or mucosal changes<br>Previous orthodontic treatment |