# Septoplasty versus septoplasty with turbinate reduction for nasal obstruction due to deviated nasal septum: a systematic review and meta-analysis*

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## Abstract

**Introduction**: Compensatory inferior turbinate hypertrophy is a common accompanying manifestation in patients with nasal obstruction due to deviated nasal septum (DNS). The grounds for inferior turbinate reduction (ITR) in this population are still not well established. This systematic review and meta-analysis aimed to evaluate the efficacy and safety of septoplasty with ITR versus septoplasty alone.

**Methods**: Computerised search in Medline, Embase, and CENTRAL was performed. Eligible for inclusion were randomised controlled trials (RCTs) comparing septoplasty to septoplasty with unilateral, contralateral, ITR in adults with DNS. Primary outcomes were health-related quality of life and nasal patency. The secondary outcome was the occurrence of adverse events. Standardised mean differences (SMD) and odds ratios (OR) with 95% confidence intervals were calculated.

**Results**: Twelve RCTs that enrolled 775 participants were found eligible. Data were reported at follow-up periods ranging from 1 month to 48 months. The pooled effect estimate showed a statistically significant improvement with unilateral, contralateral, ITR in Nasal Obstruction Symptom Evaluation scale (NOSE) scores. The rate of adverse events was significantly higher with ITR.

**Conclusions**: Unilateral reduction of the hypertrophied contralateral inferior turbinate during septoplasty resulted in better subjective relief of nasal obstruction in adults with DNS than septoplasty alone. However, caution is warranted since only few well-designed RCTs were identified.

**Key words**: nasal obstruction, nasal septum, turbinates, quality of life

## Introduction

Nasal obstruction, which is often described as fullness, congestion, or decreased airflow, is a common presenting complaint in clinical practice (1). This problem is estimated to affect 9.5-15% of the general population (2). Nasal septal deviation is the most common structural abnormality that causes nasal obstruction (2). Septoplasty, a surgical procedure to correct a deviated nasal septum (DNS), is performed to treat nasal obstruction in this clinical scenario (3). However, in patients with DNS, other nasal structures can contribute to nasal obstruction (4,5). Otolaryngologists, through radiological evidence, have noted that when the nasal septum deviates to one side, a hypertrophied inferior turbinate may occupy the extra space in the opposite nasal cavity (4,5). The current hypothesis attributes this to a compensatory mechanism to re-establish the aerodynamic balance between the two sides of the nasal cavity (6). The inferior turbinate's location and vasoactive property enable it to regulate both inspired air and upper airway resistance (6). As a result, expansion of the inferior turbinate markedly increases nasal airway resistance and alters the climatization of the inspired air, contributing greatly to symptoms of nasal airway obstruction (6). Turbinate reduction is frequently performed as part of a septoplasty procedure (7).

However, the routine performance of this procedure can be debated given the possibility of compromising nasal physiology and increasing the risk of complications [7]. Additionally, rather than the inferior turbinate, some patients' nasal obstruction may be predominantly caused by the deviated septum. As such, high-quality evidence is needed to assess the effectiveness and safety of concurrent turbinate reduction surgery. In a systematic review by van Egmond et al., septoplasty alone was compared with septoplasty and ITR [8]. However, the study was limited by including non-randomised trials. Since van Egmond et al. discussed the value of ITR, numerous randomised controlled trials (RCTs) have been published. Some RCTs showed better outcomes towards ITR, whereas others showed no discernable difference [9,10]. This systematic review aimed to evaluate the efficacy and safety of septoplasty alone compared with septoplasty and contralateral ITR in adults with nasal obstruction due to DNS.

## Materials and methods

### Study registration

This systematic review was based on a pre-specified protocol registered in PROSPERO (CRD42021293817) and reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) [11].

### Eligibility criteria

#### *Participants*

Eligible for inclusion were studies on adults with chronic nasal obstruction due to DNS and compensatory inferior turbinate hypertrophy (ITH). Studies in which septoplasty was indicated based on other complaints, such as impairment of normal sinus drainage, sleep disorders, or headaches were excluded. Studies encompassing the following patient groups were also excluded: patients with chronic rhinosinusitis or allergic rhinitis; patients with other structural abnormalities such as nasal polyps or nasal valve collapse; patients with septal perforation; patients with a history of septal surgery.

#### *Intervention and comparison*

We sought studies that compared septoplasty alone with septoplasty and contralateral ITR. Studies were included regardless of the turbinate surgery technique performed. Studies that combined septoplasty with other rhinology procedures (rhinoplasty, endoscopic sinus surgery, nasal valve surgery) were excluded. Studies in which a bilateral ITR surgery was performed were also excluded.

#### *Appropriate outcome measures*

Studies were deemed eligible if they measured outcomes before and after surgery. The primary outcomes were Health-Related Quality of Life (HR-QoL) and nasal patency. HR-QoL may be measured using patient-based questionnaires such as the Nasal Obstruction Symptom Evaluation (NOSE), Sino-Nasal Outcome Test (SNOT), and Visual Analog Scale (VAS). The NOSE is a brief, reliable, and valid 5-item questionnaire specific for nasal obstruction [12]. The VAS is a psychometric response scale used to assess subjective features in different disorders. It is a 10-centimetere line with the endpoints of "nose feels extremely clear" (0 cm) and "nose feels extremely obstructed" (10 cm) [13]. The Sino-Nasal Outcome Test 20 (SNOT-20) is a 20-item patient-reported measure of the quality of life validated for rhinosinusitis [14]. SNOT-22 is an updated version that improved the validity of the questionnaire to measure nasal obstruction by adding two items: nasal blockage and loss of taste and smell [15]. Nasal patency is objectively measured by direct examination of the area or volume of the nasal cavity, such as Acoustic Rhinometry (AR), or indirect analysis of nasal airflow and resistance, such as Peak Nasal Inspiratory Flow (PNIF) and Active Anterior Rhinomanometry (AAR). The secondary outcome was the occurrence of any adverse event (AE).

#### *Appropriate study design*

Eligible study designs were randomised and quasi-randomised controlled trials. We excluded opinion articles, conference abstracts, animal studies, observational studies, systematic reviews, and case reports. Non-English language articles and unavailable full-text articles were also excluded.

### Information sources and search strategy

A systematic search was performed on Medline, Embase, and Cochrane Central Register of Controlled Trials (CENTRAL) from database inception to December 5, 2021. No language or publication date limits were imposed. We also searched ClinicalTrials.gov for ongoing or recently completed trials. The complete search strategy is provided in Supplementary Table 1. We complemented the computerised search with a manual search that included scanning reference lists and looking for relevant publications on ResearchGate.

### Selection process

The search output was imported into EndNote Web for sorting and removal of duplicates. Four reviewers (GB, KA, AA, AH) independently screened each study in duplicate for eligibility. Titles and abstracts were assessed first for inclusion, followed by full texts. Any disagreements were resolved through discussion and consensus.

### Data extraction

Reviewers (GB, KA, AA, AH) independently extracted data in duplicate using a pre-defined data collection model. Data on the number of participants, demographics, pre-operative assessment modality, method of turbinate surgery, follow-up points, subjective outcome measure, objective outcome measure, and

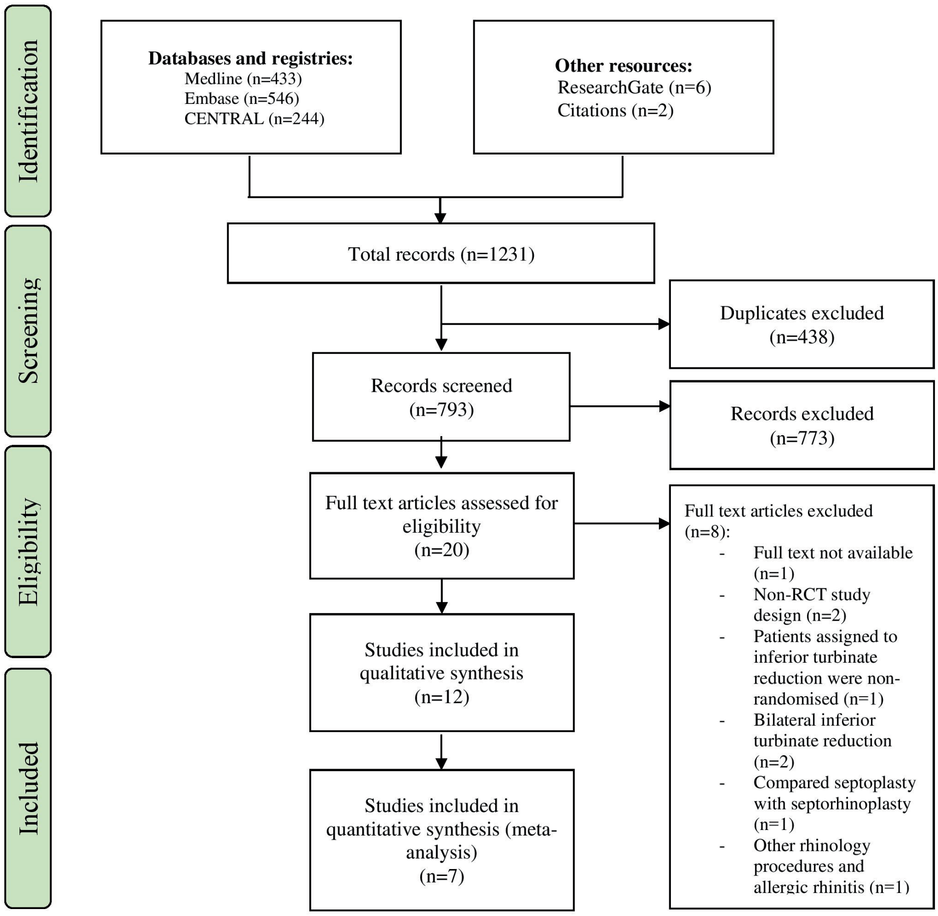


Figure 1. PRISMA flow diagram of study selection.

adverse events were obtained. We attempted to contact the corresponding authors if data was missing or solely presented by graphs.

### Risk of bias assessment

Reviewers (GB, KA, AA, AH) independently evaluated the risk of bias in duplicate using the revised Cochrane Risk of Bias 2 (RoB 2) tool [16]. This tool classifies bias risk into three categories: "low," "some concerns," and "high." Risk-of-bias VISualization (robvis) tool was used to produce figures displaying the risk-of-bias assessment results [17]. When at least ten studies were reporting the same outcome, the potential for publication bias was analysed using a funnel plot of each trial's effect versus its standard error and SMD/OR. A publication bias prevailed if the funnel plot was asymmetrical.

### Effect measures

The continuous outcomes NOSE and VAS were expressed as a standardised mean difference (SMD), while the dichotomous outcome adverse event rate was expressed as an odds ratio (OR).

### Meta-analysis

The meta-analysis was conducted using the random-effects model in RevMan (Review Manager) version 5.3 (Cochrane Collaboration). The confidence level was set at 95% with a threshold of $p<0.05$. All outcomes were pooled by the inverse variance weighting method. We tested the statistical heterogeneity using I2 and the p-value of the Chi-squared test for heterogeneity. When applicable, a subgroup analysis was performed to investigate clinical heterogeneity. If needed, a sensitivity analysis was carried out to eliminate sources of heterogeneity and assure the stability of our findings.

### Certainty of evidence

We used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) method to grade the overall certainty of the evidence for each outcome [18].

## Results

### Study selection

The combined search yielded 1231 records. Six publications were found potentially applicable by a manual search on ResearchGate, as they were not indexed by Medline, Embase, or

Table 1. Characteristics of the included studies.

| Study, year | Number of participants | | | Mean age (in years) | Gender (number of males) | Pre-operative evaluation | Type of turbinate surgery | Maximum duration of follow up (in months) | Outcomes measured | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SPL | SPL plus ITR | Total | | | | | | Subjective outcomes | Objective outcomes |
| Grymer, 1993[19] | 38 | 42 | 80 | 32 | 57 | Anterior rhinoscopy | Traditional inferior turbinoplasty | 3 | PRQ | AR |
| Ilium, 1997[20] | 38 | 42 | 80 | 32 | 57 | Anterior rhinoscopy | Traditional inferior turbinoplasty | 60 | PRQ | AR |
| Nunez, 2000[21] | 11 | 18 | 29 | 31 ± 12* | 21* | Rhinoscopy | Standard (radical) turbinectomy | 3 | PRQ | AAR |
| Devseren, 2011[22] | 33 | 34 | 67 | 30.5* | 32* | Anterior rhinoscopy and rigid endoscopy | Submucosal inferior turbinate reduction with microdebrider | 6 | VAS | AR |
| Kumar, 2016[23] | 30 | 30 | 60 | 26.5 | 41 | Nasal endoscopy and CT PNS | Standard (partial) turbinectomy | 6 | NOSE | NR |
| Shamanna, 2018[24] | 30 | 30 | 60 | NR | NR | Nasal endoscopy and CT PNS | Traditional inferior turbinoplasty | 6 | NOSE | NR |
| Karodpati, 2019[25] | 25 | 25 | 50 | NR | NR | Anterior, posterior rhinoscopy and nasal endoscopy | Standard (partial) turbinectomy | 1 | NOSE | NR |
| Sharma, 2020[26] | 20 | 20 | 40 | 24.45 ± 7.08 | 35 | Nasal endoscopy and X-ray PNS | Radiofrequency ablation | 6 | NOSE | NR |
| Samarei, 2020[9] | 79 | 80 | 159 | 35* | 59* | Anterior rhinoscopy and CT PNS | Traditional inferior turbinoplasty | 48 | NOSE, VAS | NR |
| Rajashekhar, 2020[27] | 35 | 35 | 70 | NR | 47 | Nasal endoscopy and CT PNS | Inferior turbinoplasty (unspecified) | NR | SNOT-20 | NR |
| Chowdhury, 2021[28] | 30 | 30 | 60 | NR | 22 | Anterior, posterior rhinoscopy, nasal endoscopy and radiology (X-ray and CT PNS) | Standard (partial) turbinectomy | 6 | NOSE | AAR |
| Seden, 2021[10] | 50 | 50 | 100 | 35.9* | 50* | Rhinoscopy and nasal endoscopy | Radiofrequency ablation | 3 | NOSE, SNOT-22 | PNIF, AR |

SPL: Septoplasty. ITR: Inferior turbinate reduction. CT: Computed tomography. PNS: Paranasal sinuses. NOSE: Nasal Obstruction Symptom Evaluation. VAS: Visual Analogue Scale. SNOT: Sino-Nasal Outcome Test. PRQ: Patient Reported Questionnaire. AR: Acoustic Rhinometry. AAR: Active Anterior Rhinomanometry. PNIF: Peak Nasal Inspiratory Flow. NR: Not reported. *The distribution is after the exclusion of patients who were lost to follow up.

CENTRAL. After removing duplicates, 793 records were screened by titles and abstracts, resulting in 20 studies eligible for full-text evaluation. Overall, twelve RCTs fulfilled our criteria and were included in the current review [9,10,19-28]. Five studies were excluded from the meta-analysis because of insufficient information provided [20,21,24,27,28]. Figure 1 depicts a flow diagram for study selection. Most studies included in the review by van Egmond et al. were excluded due to non-randomisation, performance of bilateral turbinate reduction, and unavailability of a full text. A list of the excluded studies is provided in Supplementary Table 2.

### Study characteristics

The total number of participants was 775, and 693 (89.4%) completed the trials. The mean age of participants ranged from 24.4 to 35.9. Most of the studies used rhinoscopy and nasal endoscopy as pre-operative assessment modalities. Others used X-ray and computed tomography of the paranasal sinuses. Five techniques of ITR were described: radical inferior turbinectomy, partial inferior turbinectomy, traditional inferior turbinoplasty, submucosal inferior turbinate reduction with microdebrider (SITRM), and radiofrequency ablation. Traditional inferior turbinoplasty and partial turbinectomy were the most common procedures performed. The maximum follow-up period ranged from 1 month to 48 months. Further details on study characteristics are provided in Table 1.

### Risk of bias within studies

In domain 1, eight studies were judged to have some con-

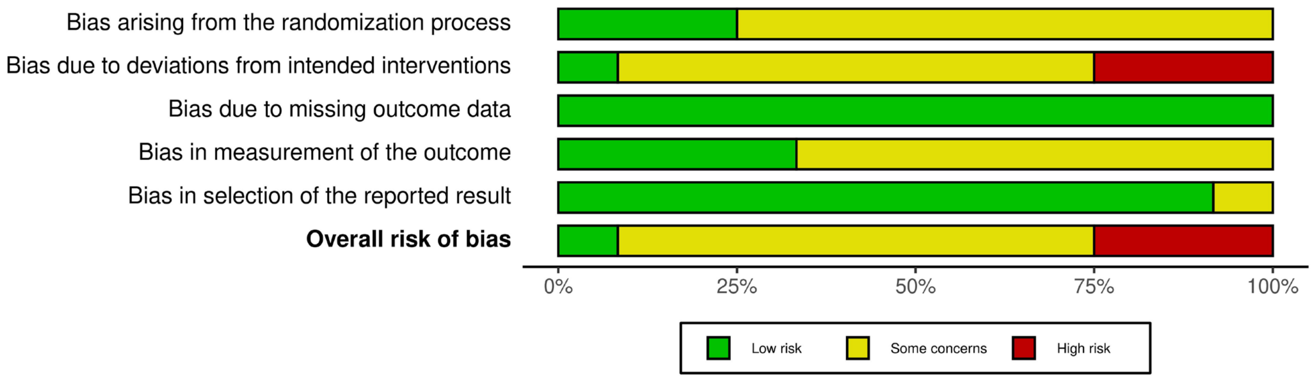


Figure 2. 'Risk of bias graph': review authors' judgements about each risk of bias item presented as percentages across all included studies.

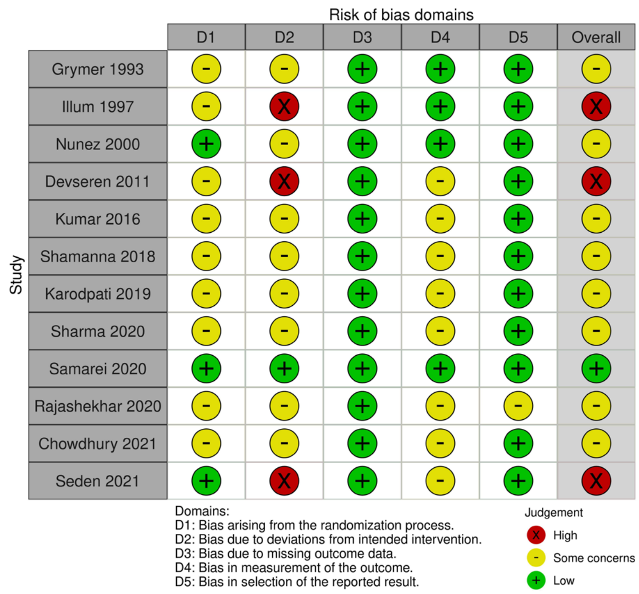


Figure 3. 'Risk of bias summary': review authors' judgements about each risk of bias item for each included study.

cerns due to a failure to demonstrate the process of allocation concealment. In domain 2, only one study blinded participants and performed an appropriate analysis on lost patients. Three studies were found to have a high risk of bias due to a failure to analyse a substantial proportion of excluded patients. Overall, only one study was at low risk of bias in all domains. Eight studies were judged to have some concerns. The remaining three studies were at high risk of bias. Figures 2 and 3 depict the full details of the risk of bias within studies.

### Effect of interventions

#### *Nasal Obstruction Symptom Evaluation*

The NOSE tool was used in seven studies (n= 529) [9,10,23-26,28]. However, two studies results could not be pooled due to a lack of data (n=120) [24,28]. Three techniques of ITR were performed: partial turbinectomy, traditional inferior turbinoplasty, and radiofrequency ablation. The pooled effect estimate of data at the maximum follow-up point showed a significant improvement favouring concurrent ITR surgery (SMD=-1.41, 95% CI -1.99 to -0.83, $p < 0.00001$, Figure 4, low-certainty evidence). Subgroup analysis by turbinate reduction techniques was conducted to investigate clinical heterogeneity. There was no significant difference between subgroups in NOSE scores (p=0.36, Figure 5). In the two studies that could not be pooled, authors reported that patients who underwent septoplasty combined with ITR had significantly better NOSE scores than the study group who underwent septoplasty alone. A funnel plot was not performed for this outcome nor the following outcomes because the analyses included less than ten studies.

#### *Visual Analogue Scale*

Two studies implemented the VAS to evaluate nasal obstruction (n=226) [9,22]. In terms of ITR techniques, Devseren et al. utilized SITRM technique, whereas Samarei et al. performed traditional inferior turbinoplasty. The pooled effect estimate of VAS scores at the maximum follow-up point revealed no significant difference between the two interventions (SMD=-0.68, 95% CI -1.96 to 0.61, p=0.30, Figure 6, moderate-certainty evidence). A subgroup analysis was not carried out given the paucity of trials reporting the VAS outcome.

#### *Sino-nasal Outcome Test*

The SNOT was used in two studies (n=170) [10,27]. Seden et al. used the SNOT-22 version and found no significant difference between the two interventions at 3 months. Rajashekhar et al. used the SNOT-20 version and found a significant improvement favouring the additional ITR surgery. However, the follow-up period was not mentioned. Due to the paucity of trials and the difference between the two test types, it was inapplicable to pool the results.

#### *Objective outcome measures*

Six trials clinically evaluated nasal patency (n=336) [10,19-22,28].

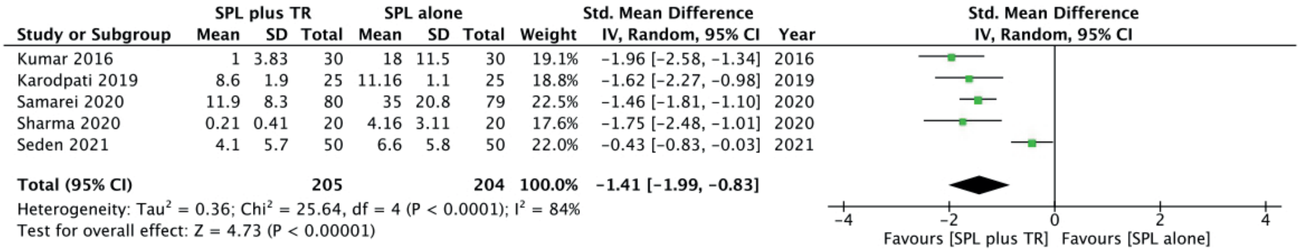


Figure 4. Forest plot of studies with data on Nasal Obstruction Symptom Evaluation (NOSE) scores.

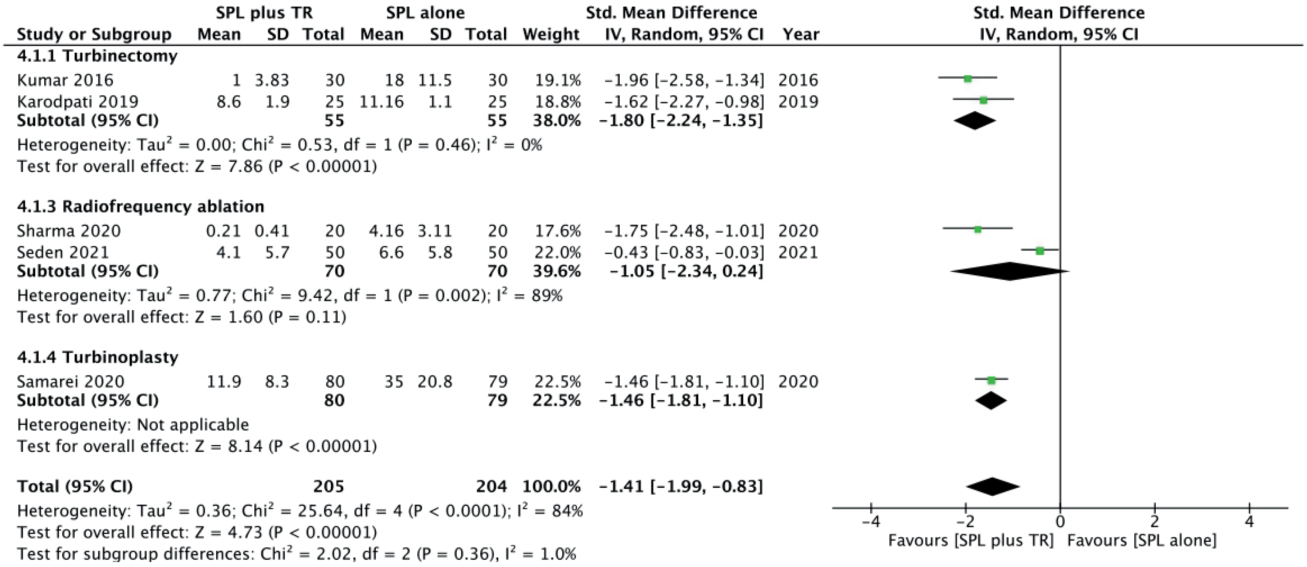


Figure 5. Forest plot of studies with data on Nasal Obstruction Symptom Evaluation (NOSE) scores sub-grouped based on turbinate reduction techniques.

Three objective measures were described (i.e., AAR, AR, PNIF). AR was the most common measure used. We could not pool the data because of insufficient information provided. All studies reported postoperative improvement in nasal patency despite the intervention assigned. However, only three studies favoured the concurrent ITR based on objective evaluation [19,22,28]. In addition, these six studies measured subjective nasal obstruction with both unspecified and specified tools. Subjective results corresponded with objective results in all trials that used a specified tool to measure nasal obstruction (i.e., NOSE, VAS, SNOT) [10, 22, 28].

### Adverse events

Six trials reported adverse events (n=446) [9,10,19,22,26]. The pooled effect estimate showed a more than twofold higher risk of complications associated with concurrent ITR surgery (OR=2.90, 95% CI 1.11 to 7.54, p = 0.03, $I^2$ = 0%, Figure 7, low-certainty evidence). The most common adverse events reported were septal perforation and nasal synechia. Other complications included secondary haemorrhage and septal haematoma. Nunez et al. reported no complications among the two groups. Chowdhury et al. could not be pooled due to insufficient information (n=60); however, the study found that an unspecified number of patients in the concurrent ITR group developed atrophic rhinitis. Among the twelve trials reviewed, the overall complication rates were variable. Nunez et al. performed radical turbinectomy and reported no complications in both groups. Partial turbinectomy was used in four studies. However, all four studies reported inadequate information about the occurrence or rate of complications. Samarei et al. and Grymer et al. used traditional inferior turbinoplasty and revealed an overall complication rate of 1.25% and 7.5%, respectively. SITRM was performed only in the study by Devseren et al., which reported a complication rate of 5.88%. Radiofrequency ablation was described in two studies with an overall complication rate between 7.5-10%. The details are provided in Supplementary Table 3.

## Discussion

### Summary of evidence

This systematic review included twelve RCTs that compared septoplasty alone with septoplasty and concurrent ITR surgery in adults with nasal obstruction due to DNS. We reviewed the results of three outcomes: HR-QoL, nasal patency, and adverse events.

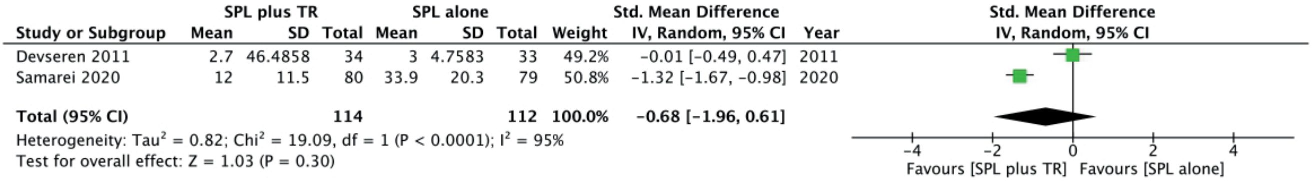


Figure 6. Forest plot of studies with data on Visual Analogue Scale (VAS) scores.

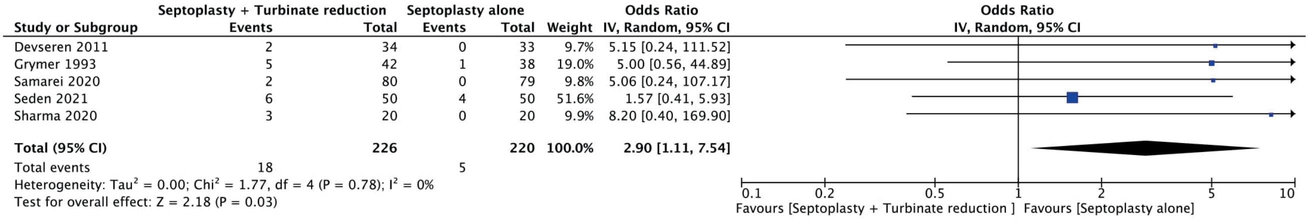


Figure 7. Forest plot of studies with data on the number of adverse events.

### Health-related quality of life

In our review, nine RCTs investigated the effect of septoplasty combined with ITR surgery on HR-QoL with a specified tool. Regardless of whether a turbinate reduction surgery was performed, all nine studies reported postoperative improvement on subjective evaluation. Three outcome measures were described: NOSE, VAS, and SNOT. The pooled effect estimate of NOSE scores revealed that septoplasty with reduction of the contralateral hypertrophied inferior turbinate resulted in better relief of nasal obstruction compared with septoplasty alone at most postoperative assessments. This finding could be explained by the structural nature of the hypertrophied inferior turbinate. In a histopathological study examining compensatory ITH, Berger et al. demonstrated that the inferior turbinate bone increased in thickness significantly more than the mucosal layers, supporting the decision to surgically reduce it during septoplasty [29]. In addition, Kim et al. used computed tomography (CT) to examine the adaptability of the hypertrophied inferior turbinate after one year of septoplasty [30]. Septoplasty resulted in a reduction in mucosal thickness; however, no changes in the conchal bone were observed [30]. Interestingly, the only study in our review that did not find an additional benefit of ITR excluded patients with persistent ITH after decongestion, providing that they were likely to have conchal bone enlargement [10]. Our finding was consistent with studies of observational design in the literature [31,32]. Yamasaki et al. investigated the impact of functional septorhinoplasty (SRP) with or without ITR [31]. The study found that patients who received an additional ITR surgery experienced statistically significant improvement in mean NOSE score compared with those who had SRP alone [31]. Balcerzak et al. reported a similar result with SNOT-20 in a retrospective analysis of 30 patients [32]. In contrast to our finding, there are studies in the literature that failed to detect significant differences in subjective measures of nasal obstruction between septoplasty alone and septoplasty with ITR [33,34]. Van Egmond et al. performed a stratified analysis of 125 participants non-randomised to septoplasty with or without ITR surgery [33]. The analysis showed no clinically relevant differences in Glasgow Health Status Inventory (GHSI) scores after 12 months of the procedures [33]. A similar finding using the NOSE tool was obtained in an RCT of SRP with or without partial turbinectomy [34]. These conflicting findings could be related to several factors, including differences in inclusion/exclusion criteria, study design, sample size, follow-up length, surgical technique for ITR, extent of ITH, and subjective measurement questionnaires.

### Nasal patency

In terms of objective evaluation, six RCTs evaluated nasal patency with three methods: AR, AAR, and PNIF. Only three studies supported the addition of ITR surgery. We could not pool objective results because of insufficient data. However, we noted that subjective results corresponded with objective results in almost all studies measuring the two outcomes with specified tools. This might support previous studies that reported a positive correlation between subjective measures and objective measures of nasal obstruction [35-37]. Like HR-QoL, the evidence on the effect of concurrent ITR surgery on nasal patency is mixed. Marais et al. prospectively followed patients who were non-randomised to septoplasty with or without partial turbinectomy [38]. The study group who underwent the combined intervention experienced the largest improvement in both minimal cross-sectional areas and peak flow fractions [38]. In contrast, some studies found no significant difference in nasal patency after the addition of ITR surgery [7,39]. Sommer et al. performed an RCT to investigate the routine performance of bilateral inferior turbinoplasty in individuals with DNS [7]. No discernable differences in AR and AAR were noted in the bilateral ITR group compared with the septoplasty/septorhinoplasty-alone group [7]. Similar AR results were reported by Lavinsky-Wolff et al., which compared septoplasty with or without submucosal diathermy of the inferior turbinate [39]. In addition to the factors previously mentioned, these conflicting results could be attributed to the variable measurements of nasal patency (i.e., volume, resistance, airflow).

### Adverse events

The safety of both interventions is one of their main challenges. In this review, the overall complication rate was low (4.84%). However, adverse events were likely under-reported, as only five studies provided adequate safety information. The most common adverse events noted were septal perforation, followed by nasal synechia. Other complications reported were secondary hemorrhage and septal haematoma. The calculated odds ratio revealed that concurrent turbinate surgery significantly increased the likelihood of adverse events. This finding was consistent with a retrospective analysis by Dąbrowska-Bień et al., which reviewed the medical records of 5639 patients assigned to septoplasty with or without inferior turbinoplasty [40]. Although Dąbrowska-Bień et al. reported a lower overall complication rate (3.42%), complications were still significantly higher in the concurrent ITR group [40]. In contrast to our review, the most frequent complication was excessive bleeding [40]. Other complications were described and significantly more often encountered in the combined intervention, such as hyposmia, prolonged healing due to infection, and temporarily reduced visual acuity [40]. Turbinate surgery can also cause empty nose syndrome (ENS)[41]. This syndrome most commonly presents as persistent nasal obstruction, which is termed "paradoxical" because physical examination and manometry results usually do not correspond to nasal obstruction symptoms [41]. ENS is highly debilitating and has a detrimental impact on patients' quality of life [41]. Among the included RCTs, Chowdhury et al. was the only study that described the occurrence of ENS in an unspecified number of patients who developed atrophic rhinitis after concurrent partial turbinectomy. The safety of turbinate surgery has been attributed to the procedure itself, which can be highly invasive and extensive, and the method of ITR [42]. There is a lack of agreement on the optimal technique of ITR [43]. In this review, we noted a discrepancy in complication rates between studies implementing different ITR techniques. However, we also noted this discrepancy in trials that used the same method of ITR. This suggests that the complications were perhaps not solely due to the ITR technique, and other factors could have played a role such as the surgeon's expertise. In the literature, there are several other techniques described, including cryosurgery, electrocautery with monopolar and bipolar techniques, and ultrasound-assisted turbinoplasty(43). The only consensus is that non-mucosal preservation surgeries such as turbinectomy should be avoided due to the higher risk of atrophic rhinitis [44].

### Strengths

We believe that this work presented an updated and inclusive evaluation of the body of evidence from RCTs on this topic. Although a previous review of five randomised and six non-randomised trials exists, most of the included studies in this review were recent and not reviewed previously. In addition, we tried to decrease the impact of confounding factors by applying strict exclusion criteria. For example, chronic rhinitis and rhinosinusitis have been linked to decreased post-surgery satisfaction; thus, studies enrolling participants with these conditions were excluded [45,46]. Since we only aimed to evaluate compensatory ITH, which is typically contralateral to the DNS, we excluded trials in which bilateral ITR was performed. Furthermore, we excluded trials that combined septoplasty with other nasal procedures. Overall, we believe this resulted in a more homogeneous population that aided in performing an original meta-analysis on this topic.

### Limitations

We acknowledge several limitations in this work. First, we were limited by the questionable quality of evidence. Applying the GRADE approach, the quality of evidence of each outcome ranged from moderate to low. Second, the follow-up of most included trials was relatively short. Only one RCT, Samarei et al., followed-up patients for at least 12 months. Although it suggested that ITR might improve the long-term success of septoplasty, we still cannot generalise this finding to the rest of the trials included. Third, we were limited by the small number of RCTs. Fourth, the meta-analysis did not comprise evidence from objective measures. Since multiple reports found a strong correlation between valid subjective measures and objective measures [35-37], we believe that postoperative patient perception of relief with a validated instrument might serve as a reliable clinical indicator of the outcome of surgery in the absence of objective evaluation. However, subjective measures are personality-dependent and can be biased, especially in trials in which no blinding is performed. Finally, this review did not demonstrate the optimal technique(s) of ITR. Head-to-head RCTs comparing different turbinate reduction techniques are needed to optimise the overall success of the procedure.

## Conclusions

### Implication for practice

The current body of evidence supports the reduction of the contralateral hypertrophied inferior turbinate to achieve better subjective relief of nasal obstruction. Nevertheless, we advise caution in adopting this finding given the potential limitations presented.

**Implication for research**

Future well-designed RCTs trials are warranted and should complement valid subjective measures with objective measures and examine the long-term effects of both procedures. In addition, we recognised a vast array of turbinate reduction techniques reported and emphasised the importance of continued research to identify the most effective and safe ones.

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## Authorship contribution

GB is the main author of this publication and contributed to the research idea, data extraction, risk of bias assessment, creating the tables, and writing the manuscript. KA contributed to the research idea, data extraction, and risk of bias assessment. AG contributed to the design/protocol of the study, creating the data extraction model, statistical analysis/interpretation, and certainty of evidence assessment. AA and AH contributed to the data extraction and risk of bias assessment. MAls contributed to the discussion of the manuscript and statistical analysis. MAlg supported the manuscript with additions and corrections. HA is the senior author who supervised the project. All the authors have read and approved the final manuscript.

## Conflict of interest

The authors declare that they have no conflict of interest.

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**This manuscript contains online supplementary material**

## SUPPLEMENTARY MATERIAL

Supplementary Table 1. Search strategy.

| Medline, Embase, and CENTRAL (n=1,223): | |
|---|---|
| 1. | exp Nasal Septum/ |
| 2. | exp Nasal Obstruction/ or exp Turbinates/ or exp Nose Deformities, Acquired/ |
| 3. | Nasal Septum$.mp. |
| 4. | Nasal Obstruction$.mp. |
| 5. | Septal Deviation$.mp. |
| 6. | Turbinates$.mp. |
| 7. | Deviated Nasal Septum$.mp. |
| 8. | Deviated Septum$.mp. |
| 9. | Nasal congestion$.mp. |
| 10. | Septal deformity$.mp. |
| 11. | Nose Deformity$.mp. |
| 12. | Deviated Nose$.mp. |
| 13. | Turbinates hypertrophy$.mp. |
| 14. | Concha$.mp. |
| 15. | 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 |
| 16. | exp Rhinoplasty/ |
| 17. | Rhinoplasty$.mp. |
| 18. | Septoplasty$.mp. |
| 19. | Turbinoplasty$.mp. |
| 20. | Turbinectomy$.mp. |
| 21. | Septal reconstruction$.mp. |
| 22. | Turbinate Reduction$.mp. |
| 23. | exp Nasal Surgical Procedures/ |
| 24. | Nasal surgery$.mp. |
| 25. | 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 |
| 26. | exp Randomized Controlled Trial/ or exp Clinical Trial/ |
| 27. | Trial$.mp. |
| 28. | 26 or 27 |
| 29. | 15 and 25 and 28 |

Supplementary Table 2. List of excluded studies.

| | | |
|---|---|---|
| Nasseem, 2009 | Turbinate reduction during septoplasty; to do it or not? Clinical and radiological study | Does not meet the criteria - Full text not available |
| Stewart, 2004 | Outcomes after nasal septoplasty: Results from the Nasal Obstruction Septoplasty Effectiveness (NOSE) study | Does not meet the criteria - Not randomized |
| Marais, 1994 | Minimal cross-sectional areas, nasal peak flow and patients' satisfaction in septoplasty and inferior turbinectomy | Does not meet the criteria - Not randomized |
| van Egmond, 2019 | Septoplasty with or without concurrent turbinate surgery versus non-surgical management for nasal obstruction in adults with a deviated septum: a pragmatic, randomised controlled trial | Does not meet the criteria – Patients assigned to turbinate reduction were non-randomized |
| Lindemann, 2008 | Early influence of bilateral turbinoplasty combined with septoplasty on intranasal air conditioning | Does not meet the criteria - Bilateral turbinate reduction |
| Sommer, 2019 | Value of turbinoplasty in rhinosurgery - a controlled randomized study | Does not meet the criteria - Bilateral inferior turbinate reduction |
| Martin, 2021 | Treatment success after rhinosurgery: an evaluation of subjective and objective parameters | Does not meet the criteria - Compared septoplasty with septorhinoplasty |
| Lavinsky-Wolff, 2013 | Effect of turbinate surgery in rhinoseptoplasty on quality-of-life and acoustic rhinometry outcomes: a randomized clinical trial. | Does not meet the criteria – Other rhinology procedures, allergic rhinitis |

Supplementary Table 3. The rate of adverse events in studies with data on post-operative complications with the turbinate reduction technique performed.

| Technique | Study | Complications | | Total |
|---|---|---|---|---|
| | | SPL group | SPL plus ITR group | |
| Traditional inferior turbinoplasty | Grymer, 1993 [19] | 1/38 (2.63%) | 5/42 (11.90%) | 6/80 (7.5%) |
| | Samarei, 2020 [9] | 0/79 (0%) | 2/80 (2.5%) | 2/159 (1.25%) |
| Standard (radical) turbinectomy | Nunez, 2000 [21] | 0/11 (0%) | 0/18 (0%) | 0/29 (0%) |
| Submucosal resection with microdebrider | Devseren, 2011 [22] | 0/33 (0%) | 2/34 (5.88%) | 2/67 (2.98%) |
| Radiofrequency ablation | Seden, 2021 [10] | 4/50 (8%) | 6/50 (12%) | 10/100 (10%) |
| | Sharma, 2020 [26] | 0/20 (0%) | 3/20 (15%) | 3/40 (7.5%) |
| **Total** | | 5/231 (2.16%) | 18/244 (7.37%) | 23/475 (4.84%) |

SPL: septoplasty, ITR: Inferior turbinate reduction.