

Systematic Review of Surgical Interventions for Inferior Turbinate Hypertrophy

American Journal of Rhinology & Allergy

2023, Vol. 37(1) 110–122

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DOI: 10.1177/19458924221134555

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Abstract

Background: Various surgical interventions exist for treatment of inferior turbinate hypertrophy (ITH). Though mucosal-sparing techniques are generally preferred, there is lack of consensus on the optimal technique.

Objective: This systematic review sought to evaluate the evidence for treatment of bilateral nasal obstruction via inferior turbinate reduction (ITR) and provide a meta-analysis of expected results of various techniques.

Methods: PubMed, Scopus, Cochrane Library databases were queried to include articles describing surgical treatment for ITH. Exclusion criteria were concurrent nasal procedures or non-mucosal ITH. Primary outcomes included visual analog scale for nasal obstruction, nasal cavity volume by acoustic rhinometry, and resistance by anterior rhinomanometry. Subgroup analyses assessed outcomes by rhinitis diagnosis and length of follow-up, and radiofrequency ablation (RFA) was compared to microdebrider-assisted turbinoplasty (MAIT).

Results: A total of 1870 studies were identified with 62 meeting inclusion criteria. Reported techniques included turbinectomy, submucosal resection, RFA, MAIT, laser, or electrocautery.

All techniques demonstrated significant improvements in nasal obstruction using the visual analog scale. Further comprehensive physiologic data for RFA, MAIT, and laser was available and, compared to baseline, these techniques resulted in significant improvements in nasal resistance, nasal cavity volume, and nasal airflow. Six studies directly compared RFA and MAIT with statistically similar results on VAS, nasal cavity volume, and resistance with median follow-up time of 3.5 months. Assessment of VAS congestion over time reveals peak benefit is achieved between 3–6 months follow-up.

Conclusions: All reviewed ITR techniques improve patient-reported nasal obstruction. RFA and MAIT provide comparable improvements in patient-reported and physiologic nasal airflow outcomes and while benefits are sustained long-term, the peak benefit for both techniques appears to be achieved within the first year.

Keywords

allergic rhinitis, non-allergic rhinitis, visual analog scale, inferior turbinate reduction, inferior turbinate hypertrophy, radiofrequency ablation, laser, microdebrider-assisted turbinoplasty, submucosal resection, turbinectomy

Introduction

Inferior turbinate hypertrophy (ITH) is among the most common causes of nasal airway obstruction, most frequently due to allergic or non-allergic rhinitis.^{1,2} In allergic rhinitis (AR), the mucosal epithelium is the principal site of immunoglobulin (Ig)E-mediated allergic reactions and chronic inflammation, resulting in mucosal swelling and hypertrophic changes,³ whereas in non-allergic rhinitis (NAR), mucosal inflammation and tissue swelling occurs as a result of non-allergic triggers, such as parasympathetic imbalance in vasomotor rhinitis.^{4,5} First-line treatment for nasal congestion secondary to ITH includes antihistamines, corticosteroids sprays, or immunotherapy. Cases refractory to medical therapy are deemed candidates for inferior turbinate reduction (ITR) to reduce the volume of inferior

turbinate tissue while preserving the nasal mucosa and its physiologic functions that include warming and humidification of inspired air.⁶ Various techniques for ITR exist, including radiofrequency ablation (RFA), microdebrider-assisted inferior turbinoplasty (MAIT), electrocautery, and laser-assisted turbinoplasty, submucosal resection (SMR), and partial or total turbinectomy. Given the numerous

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approaches, there remains a lack of consensus on the optimal technique.⁷

The objective of this study is to provide a systematic review of the evidence for treatment of bilateral nasal obstruction following ITR, and to provide a meta-analysis of expected results of using various techniques. Additionally, studies comparing two techniques were analyzed to determine whether there is a superior method. The primary outcome measures of interest were improvement in nasal obstruction symptoms using the visual analog scale (VAS; 0–10 cm) and physiologic measures of nasal resistance and airflow.

Methods

Search Strategy

This study was conducted according to Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines.¹⁶ Studies were identified by performing a systematic search of English language literature in PubMed, Scopus, and Cochrane Library databases from inception to April 30, 2021. The following search terms were used: turbinate hypertrophy-related terms (eg, “nasal obstruction”, “inferior turbinate hypertrophy”), rhinitis-related terms (eg, “rhinitis”, “nonallergic rhinitis”) and inferior turbinate surgery-related terms (eg, “submucosal resection”, “radiofrequency”, “turbinate reduction”). Reference lists of relevant articles were reviewed and cross-referenced to identify additional articles. Following initial title and abstract screening, studies that met inclusion criteria underwent full-text review by 2 reviewers (K.Z., R.P.). Any conflicts were resolved by discussion with a third reviewer (S.A.N.).

Selection of Articles and Outcome Definition

Studies that met the following criteria were included: (1) Patients with inferior turbinate hypertrophy or rhinitis undergoing surgical inferior turbinate reduction and (2) Studies reporting on differences in outcomes before and after surgery. Exclusion criteria were as follows: Studies reporting on patients with other concomitant conditions causing nasal obstruction (eg, deviated nasal septum, nasal polyps, sinusitis, concha bullosa, mucocoeles, collapse of alar cartilage, nasal valve abnormalities, tumors of the nose or paranasal sinuses), prior or concurrent nasal/sinus surgery (eg, concomitant functional endoscopic sinus surgery (FESS) and/or septoplasty), and pediatric populations (under the age of 18 years).

Specific endpoints of the studies included visual analog scale (VAS) graded from 0 to 10 cm, with participants rating 0 as no symptoms and 10 as the most severe symptoms. Specific VAS domains were collected including nasal obstruction, rhinorrhea, sneezing, and nasal itching. Physiologic endpoints included change in nasal resistance measured by active anterior rhinomanometry (in Pa/cm³/second at 150 Pa), minimal cross-sectional area (MCA)

measured by acoustic rhinometry (in cm²), and nasal airflow (in cm³/second at 150 Pa).

Surgical Techniques

The surgical techniques for inferior turbinate surgery were grouped into five categories: 1) turbinectomy which was defined by a procedure in which the inferior turbinate was removed via total, partial, and classical submucosal resection using cold steel instruments; 2) microdebrider-assisted turbinoplasty [Microdebrider (XOMED Medtronic)] which was defined by submucosal resection of the inferior turbinate with microdebrider; 3) radiofrequency ablation [Coblator, Arthrocare ENT; Somnoplasty, Gyrus ACMI ENT] for any procedure relying on the use of radio waves to create heat in order to cause tissue fibrosis and shrinkage; 4) electrocautery techniques (monopolar/bipolar probe, diathermy electrode, straight-tip electrode) which make use of an electrical current to destroy tissue on the inferior turbinate; and 5) laser-assisted turbinoplasty (carbon dioxide, diode, potassium titanyl phosphate) that uses light energy to ablate tissue.

Data Extraction and Quality Assessment

Two study investigators (K.Z., R.P.) extracted data using a pre-defined template for author, year, study design, patient demographics, diagnostic criteria for ITH and/or rhinitis, surgical instrument used, follow-up time, and pre- and post-operative mean and standard deviation for outcomes.

Each study was critically appraised to assess level of evidence using the Oxford Center for Evidence-Based Medicine criteria.²⁴ Risk of bias was assessed according to the Cochrane Handbook for Systematic Reviews of Interventions version 6.0 for randomized studies²⁵ and the Cochrane Handbook ROBINS-I tool for non-randomized studies.⁸ For randomized studies, the following items were graded: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias. For non-randomized studies, confounding, selection of participants, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, and selection of reported results were graded. Each item was assigned low, unclear, or high risk of bias.

Data Synthesis and Statistical Methods

Meta-analysis of continuous measures (mean difference between pre-op vs post-op with VAS obstruction and VAS rhinorrhea) were performed with Cochrane Review Manager (RevMan) version 5.4 (The Cochrane Collaboration 2020). Both fixed effects and random effects model were used.^{9,10} This assumption is tested by the heterogeneity test or I² statistic. If this test yields a low probability value ($p < .05$), then

there is a high likelihood the fixed-effects model is invalid and the random-effects model is more appropriate. The random-effects model incorporates both the random variation within the studies and the variation between the different studies. Additionally, Egger tests with funnel plots were performed to further assess the risk of publication bias.^{11,12} Potential publication bias was evaluated by visual inspection of the funnel plot which statistically examines the asymmetry of the funnel plot. In a funnel plot, the treatment effect is plotted on the horizontal axis and the standard error is plotted on the vertical axis. The vertical line represents the summary estimated derived using fixed effect meta-analysis. Two diagonal lines represent (pseudo) 95% confidence limits (effect ± 1.96 SE) around the summary effect for each standard error on the vertical axis. These show the expected distribution of studies in the absence of heterogeneity or of selection bias. In the absence of heterogeneity, 95% of the studies should lie within the funnel defined by these diagonal lines. Publication bias results in asymmetry of the funnel plot. A p value of <0.05 was considered to indicate a statistically significant difference for all statistical tests.

Results

Study Selection

The literature search identified 2255 articles. After removing duplicates, 1643 articles were further excluded after applying

the selection criteria. Following full text review, 62 articles met inclusion criteria (Figure 1). Critical appraisal of studies indicated an acceptably low risk of bias for the majority of included studies. Potential sources of unclear bias were most pronounced in performance bias, reporting bias, and other bias in the randomized studies. All the nonrandomized studies were considered low risk. A funnel plot with Egger's test (-2.754 , $p=0.1357$) demonstrated all studies were within the funnel except for two with no asymmetry, suggesting little publication bias (Figure 2).

Included Studies

Included articles consisted of the following surgical treatments for inferior turbinate hypertrophy: 44 studies for RFA, 16 MAIT, 10 laser, 6 electrocautery, and 8 with turbinectomy/surgical submucosal resection (SMR). Some studies directly compared RFA to other techniques, including 6 studies comparing RFA to MAIT, 6 comparing RFA to electrocautery and 3 comparing RFA to SMR/turbinectomy. Studies were from 16 different countries ranging years 1996–2021 of publication. A list of included studies is shown in Table 1.

All studies were prospective in design, with 28 (45%) randomized. The mean sample size was 114 subjects (range 10–3219) with an overall mean age of 36.07 (range 22.97–75.50). Twenty-six (41.9%) studies reported on patients with allergic rhinitis, 17 (27.4%) included NAR or other types of rhinitis. Most studies used local anesthesia ($n=56$,

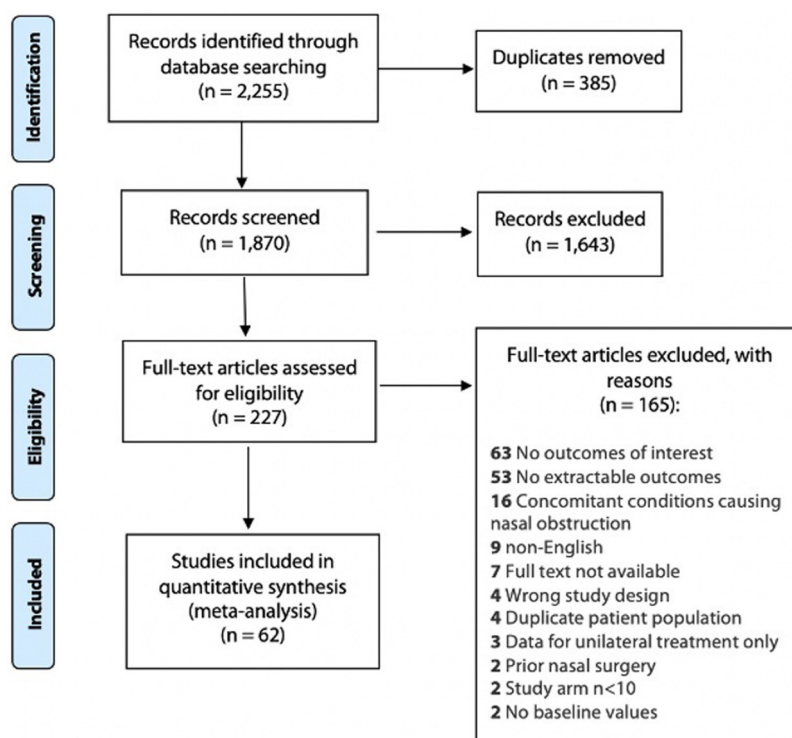


Figure 1. Flow diagram of study selection.

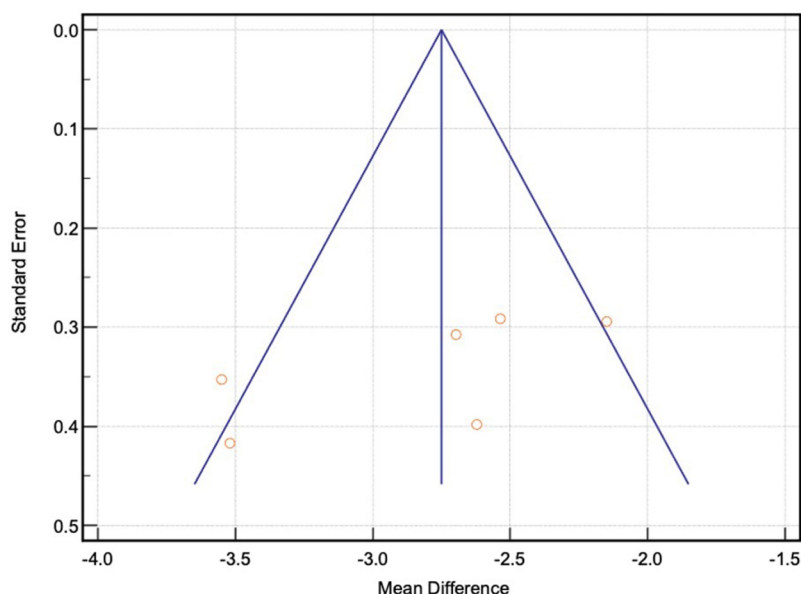


Figure 2. Funnel plot with Egger's test of all included studies.

94.9%) and 5 studies performed concurrent out-fracture. The median follow-up time was 6 months (mean 9.6 months, range 1 week – 7.8 years).

The primary outcome data (ie, VAS scores and physiological nasal airflow outcomes) are demonstrated in Table 2, and outcomes from studies directly comparing two different techniques is shown in Figure 3.

Patient-Reported Outcomes

Table 2 shows the mean difference between baseline and post-operative VAS (0–10cm) for nasal obstruction, rhinorrhea, sneezing, and nasal itching. Random effects modelling demonstrated significant improvement on VAS obstruction using all techniques, including RFA, MAIT, electrocautery, laser, and SMR/turbinectomy. MAIT appears to have resulted in the greatest mean difference between baseline and post-op VAS obstruction (with a 5.24-point improvement) and rhinorrhea (3.79-point improvement post-operatively). For studies directly comparing two techniques, greater improvement in nasal obstruction was seen for patients treated by MAIT compared to RFA (MD 4.81 vs 2.64), however this was not statistically significant ($p = 0.09$) (Figure 3A). Similar mean differences in VAS obstruction were achieved when directly comparing RFA to electrocautery and RFA to SMR/turbinectomy (Table 3).

Additionally, data was available for VAS sneezing and nasal itching ratings following RFA, demonstrating a 2.09-point improvement in sneezing and a 1.59-point improvement in nasal itching.

Physiologic Outcomes

Random effects modelling demonstrated a 1.35-point improvement in nasal resistance after RFA, a 1.80-point

improvement after MAIT, and a 0.78-point improvement after laser. On acoustic rhinometry, a 0.40 increase in cross-sectional area (CSA) was seen after RFA and 1.94-point increase in CSA after MAIT. For nasal airflow results, a 2.55 cm³/sec improvement was seen after RFA, and 0.90 cm³/sec improvement after laser (Table 2).

AR Versus NAR Outcomes

Three studies analyzing RFA reported on VAS nasal obstruction using allergic rhinitis and non-allergic rhinitis subgroups. After treatment with RFA, similar mean differences were seen for both AR and NAR groups post-operatively (4.23 [3.86–4.61] vs 4.63 [4.18–5.07], both groups with $p < 0.0001$) (Figure 4).

Follow-up Time RFA Versus MAIT

Results of VAS obstruction for all RFA and MAIT studies were stratified by length of follow-up. For RFA, earlier time points (3–6 months and 6–8 months follow-up) showed a significant difference in VAS obstruction compared to lengthier follow-up at 1–5 years. While post-procedure results were significantly improved from baseline at all time points, a progressive recurrence of nasal obstruction symptoms was observed with lengthier follow-up for RFA (VAS weighted mean increased from 3.02 to 3.14 to 3.68) (Figure 5).

For MAIT, a significant difference was seen when comparing 3–6 months of follow-up to 1–5 years of follow-up, with worse obstruction ratings at lengthier follow-up time (VAS weighted mean 1.68 to 2.53) (Figure 5).

Table 1. Characteristics of Included Studies.

Study	Country	OLE	No. of patients	Mean age (years)	Follow-up Time	Anesthesia	Technique	Surgical Instrument	Rhinitis diagnosis
Akagun 2016	Turkey	2	40	32.15	3 mo	Local	RFA, MAIT	Somnoplasty Model 735000 RF probe (Gyrus), Microdebrider (Medtronic Xomed)	-
Albu 2014	Romania	3	63	35.45	1 y	General	MAIT	Microdebrider (Medtronic Xomed)	AR
Assanassen 2014	Thailand	3	48	44	1.5–2.5 mo	Local	RFA	RF device (Somnus Medical Technologies, Sutter Medizintechnik)	AR, NAR
Atef 2011*	Egypt	3	10	32.2	3 mo	General	Turbinectomy (total/partial)	Powerstar Bipolar scissor (Ethicon)	-
Bahadir 2012	Turkey	3	35	31	2 mo	Local	RFA	RF Control Unit (Gyrus)	NAR
Bakshi 2017*	India	2	86	34.73	1 y	Local	RFA, Turbinoplasty	RF probe (Ellman Surgitron), 15 blade	-
Banhiran 2010	Thailand	3	28	43.5	2 mo	Local	RFA	Temperature Controlled RF probe (Somnoplasty model S2)	AR, NAR
Banhiran 2015	Thailand	2	84	46.2	1 y	Local	RFA	Temperature Controlled RF probe (Somnoplasty model S2), Bipolar RF probe (Select Sutter)	AR, NAR
Caffier 2008	Germany	3	42	44	6 mo	Local	Laser	Diode laser (Lumenis)	RM
Cakli 2012	Turkey	3	62	41.61	1 y	Local	Laser	Multidiode S30 laser (Intermedic Arfran SA)	NAR
Cavaliere 2005	Italy	2	75	22.97	3 mo	Both	RFA, SMR	Model G1 RF Control Unit (Somnus)	AR, VMR
Chen 2008*	Taiwan	2	160	39.2	3 y	Local	MAIT, SMR	Microdebrider (Medtronic Xomed), elevator & Hartmann forceps (Explorent Surgical Instruments)	AR
Civelek 2010	Turkey	2	40	25	1.5 mo	Local	RFA	Celon choncha probe (Celon ProBreath)	-
Cukurova 2011	Turkey	3	148	32.7	6 mo	Local	RFA	Reflex 45 probe mounted on ENTec Coblator device (Arthrocare)	NAR
Desvant 2018	France	3	65	40	3 mo	-	RFA, MAIT	-	-
Dogan 2017	Turkey	2	82	25.45	3 mo	Local	RFA	RadioSURGE 2200 (Meyer HAAKE GmbH Medical Innovations)	NAR
El Henawi 2011	Egypt	2	46	25.65	6 mo	Local	MAIT, SMR	Microdebrider (Hall Linvatec)	-
Ercan 2014*	Turkey	2	60	28.9	2 mo	Local	RFA, SMR	Quantum QMR Generator (Telea)	AR, VMR
Fischer 2000	Germany	3	22	44.8	3 mo	Local	RFA	RF generator (Somnus Medical Technologies)	NAR
Gindros 2010	Greece	2	60	32.2	6 mo	Local	RFA, Cautery	Reflex Ultra 45 wand (ArthroCare ENT Coblator II Surgery System), Abbey diathermy needle electrode (Downs Surgical)	NAR
Gunhan 2011	Turkey	2	55	34.8	14 mo	Local	RFA	Model S2 Somnoplasty device (Gyrus)	AR
Harju 2021	Finland	2	98	-	1 y	Local	RFA, Laser, MAIT	RF Generator (Sutter), FOX Laser (A.R.C Laser GmbH), Microdebrider (Medtronic Xomed)	AR, NAR
Hegazy 2014	Saudi Arabia	2	70	23.5	6 mo	General	RFA, MAIT	Coblator II (ENTec, ArthroCare), Microdebrider (Medtronic Xomed)	-
Hirunwiwatkul 2012	Thailand	2	79	48.35	1 week	Local	RFA	RF generator (Hemosac-300)	-

(continued)

Table 1. Continued.

Study	Country	OLE	No. of patients	Mean age (years)	Follow-up Time	Anesthesia	Technique	Surgical Instrument	Rhinitis diagnosis
Huang 2006	Taiwan	3	50	31.2	1 y	Local	MAIT	Microdebrider (Medtronic Xomed)	AR
Hussain 2020	India	3	53	-	3 mo	Local	Laser	CO ₂ Laser	AR, NAR
Karakurt 2021*	Turkey	2	58	32.72	6 mo	Local	RFA	G3 RF Generator (Gyrus)	NAR
Kaymakci 2014*	Turkey	2	60	34.65	1 mo	Local	RFA	G3 RF Generator (Gyrus)	AR (30%), NAR (70%)
Kilavuz 2014	Turkey	2	36	-	2 mo	Local	RFA, Cautey	RF Generator (Gyrus), Monopolar electrocautery device	-
Lee 2006	South Korea	2	60	28.85	14.5 mo	Local	RFA, MAIT	RF device (Somnus Medical Technologies), Microdebrider (Medtronic Xomed)	NAR
Lee 2010	South Korea	3	37	28.8	3 mo	Local	MAIT, Laser	Microdebrider (Medtronic Xomed), CO ₂ Laser (Sharplan)	-
Lee 2013	South Korea	2	60	31.05	1 y	Local	MAIT	Microdebrider (Stryker Instruments)	AR
Leong 2010	UK	3	13	-	8 mo	-	RFA	Coblation device (ArthroCare)	-
Li 1998	USA	3	22	41.1	2 mo	Local	RFA	RF generator (Somnus Medical Technologies)	AR, VMR
Lin 2010	Taiwan	3	101	29.1	5 y	Local	RFA	Model S2 RF Control Unit (Somnus Medical Technologies)	AR
Liu 2009	Taiwan	2	120	37.5	3 y	Local	RFA, MAIT	ENTec Coblator Plasma Surgery System (ArthroCare), Microdebrider (Medtronic Xomed)	AR
Mehta 2019	India	2	150	-	1 y	Both	RFA	Turbinator coblation wand, Reflex Ultra coblation wand	-
Min 1996	South Korea	3	53	31.2	6 mo	Local	Laser	Diode laser (Diomed)	NAR
Mora 2009	Italy	3	50	23	6 mo	Local	Cautey	Bipolar electrode	AR
Neri 2016	Italy	3	18	36.77	4 y	Local	MAIT	Microdebrider (Medtronic Xomed)	-
Parida 2011	India	3	47	30.86	6 mo	Local	RFA	Ellman Surgitron FFPF EMC Radio-Surgical Device (Ellman)	AR
Pecorari 2021	Italy	3	113	45.01	3 mo	Local	RFA	RF generator (CelonLab ENT)	AR (37%), NAR
Pelen 2016	Turkey	2	40	38.65	2 mo	Local	RFA, MAIT	Ellman Surgitron FFPF EMC (Ellman), Microdebrider (Medtronic Xomed)	(35%), RM (17%) AR (30%), HR (70%)
Powell 2001	USA	2	22	53	1 mo	Local	RFA	Temperature Controlled RF electrode (Somnus Medical Technologies)	-
Prokopakis 2014	Greece	2	3219	41.3	1 y	Local	RFA, Electrocautery, Laser	CO ₂ Laser (Sharplan), Bipolar turbinate	AR

(continued)

Table 1. Continued.

Study	Country	OLE	No. of patients	Mean age (years)	Follow-up Time	Anesthesia	Technique	Surgical Instrument	Rhinitis diagnosis
Romano 2015	Italy	2	158	-	3 mo	Both	MAIT, Turbinectomy (total)	reduction electrode (Surgitron Dual Frequency, Ellman), Straight-tip electrode StortzDrillcutx 4071 1070 microdebrider, turbinate scissors	-
Sahin-Yilmaz 2014	Turkey	3	53	35.7	6 mo	Local	RFA	RF device (Curis, Sutter Medizintechnik)	-
Salzano 2009	Italy	3	80	-	2 mo	Both	RFA, Electrocautery, HF diathermocoagulation	ENT Coblator Plasma Surgery System (Celon), HF bipolar diathermocoagulation device (Timed TD 50, Micropulse AIRD), straight tip electrode (Telea-Vesalius)	NAR
Sozen 2013	Turkey	2	40	32.85	3 mo	Local	RFA	RF device (CelonLab ENT)	NAR
Supiyaphun 2003	Thailand	3	48	33.29	2 mo	Local	Laser	KTP laser (Laserscope)	AR (85%), VMR (10%), HR (5%)
Tatar 2014	Turkey	3	30	34	6 mo	Local	RFA	Temperature controlled RF thermal ablation device (Surgitron, Ellman)	-
Tawaranurak 2020	Thailand	2	28	52.35	6 mo	Local	RFA, Cautery	Quantum Molecular Resonance generator (Quantum; Telea Electronic Engineering), bipolar tip (Bipolar RaVoRTM needle electrode, Sutter)	-
Testa 2006	Italy	3	308	31.4	7.8 y	-	Laser	CO ₂ Laser	AR (55%), HR (45%)
Tosun 2005	Turkey	3	20	29.2	6 mo	Local	RFA	RF generator (Ellman Surgitron EMC unit)	VMR
Turk 2018	Turkey	3	59	37	6 mo	Local	RFA	RF generator (CelonLab ENT)	AR (39%), NAR (61%)
Uluyol 2016	Brazil	3	43	30.87	2 mo	Local	RFA, Cautery	RF probe, bipolar probe	NAR
Uz 2014	Turkey	3	39	36.3	2 mo	Local	RFA	Gyrus ENT Sonnoptasty device (Gyrus)	NAR
Volk 2010	Germany	3	41	42.4	2 mo	Local	Laser	Diode laser (Ceralas D15 Evolve, CeramOptec GmbH)	VMR
Wu 2008	Taiwan	3	70	35.1	1 y	Local	MAIT	Microdebrider (Medtronic Xomed)	AR (59%), NAR (41%)
Yilmaz 2006	Turkey	3	22	32	6 mo	Local	RFA	RF device (Surgitron, Ellman)	-
Yu 2015	South Korea	3	35	75.5	6 mo	Local	RFA	RF Generator BM-780 (Select-Sutter Medizintechnik)	NAR
Zhong 2019	China	2	66	43.31	1 y	Local	RFA	-	AR

*Studies performing concurrent outfracture

RFA = radiofrequency ablation, MAIT = microdebrider-assisted inferior turbinoplasty, SMR = submucosal resection, HF = high frequency, RM = Rhinitis medicamentosa, VMR = vasomotor rhinitis, HR = hypertrophic rhinitis

Table 2. Mean Difference Between pre- and post-Operative VAS Scores (0–10 Scale) and Physiologic Outcomes.

Patient-reported outcomes			
Technique	N studies	N patients	VAS Obstruction MD [95%CI]
RFA	38	2284	2.98 [2.49, 3.46]*
MAIT	12	523	5.24 [4.33, 6.14]*
Electrocautery	6	1388	3.89 [2.38, 5.39]*
Laser	5	1223	4.64 [3.32, 6.05]*
SMR/turbinectomy◇	5	137	4.74 [3.27, 6.20]*
VAS Rhinorrhea			
RFA	17	1813	2.49 [1.97, 3.01]*
MAIT	7	306	3.79 [2.86, 4.72]*
VAS Sneezing			
RFA	15	1293	2.09 [1.50, 2.68]*
VAS Nasal Itching			
RFA	6	932	1.59 [1.04, 2.13]*
Physiologic outcomes			
Technique	N studies	N patients	Active anterior rhinomanometry (AAR) (Pa/cm ³ /s at 150 Pa) SMD [95%CI]
RFA	10	388	1.35 [0.67, 2.03]*
MAIT	5	198	1.80 [0.35, 3.24]†
Laser	3	409	0.78 [0.40, 1.17]*
Minimal cross-sectional area (MCA) (cm ²)			
RFA	8	320	0.40 [0.10, 0.70]†
MAIT	6	234	1.94 [0.99, 2.90]*
Nasal airflow (cm ³ /sec at 150Pa)			
RFA	3	82	2.55 [0.08, 5.01]†
Laser	3	131	0.90 [0.55, 1.26]*

◇ Classic surgical SMR/turbinectomy with incision followed by forceps/scissor dissection (performed without microdebrider)

*Test for overall effect $p < 0.0001$ for baseline versus postoperative MD† Test for overall effect $p < 0.01$

Abbreviations: MD- mean difference, SMD-standardized mean difference, RFA-radiofrequency ablation, MAIT-microdebrider assisted inferior turbinoplasty, SMR-submucosal resection

Discussion

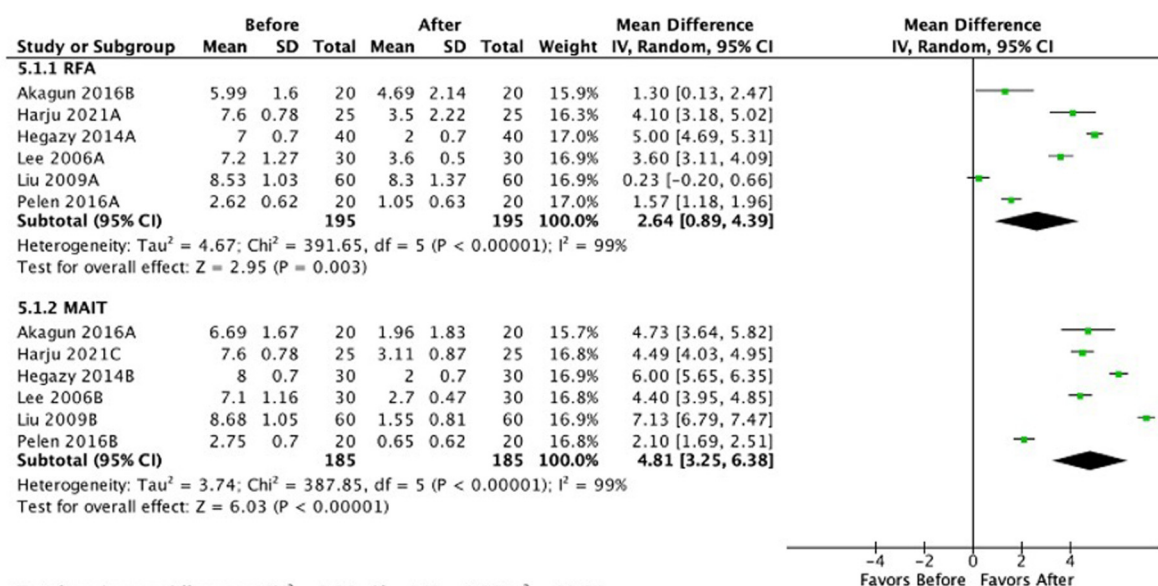
The purpose of this study is to evaluate both patient-reported and physiologic outcome measures for existing surgical techniques for ITR. All techniques significantly improved nasal obstruction post-operatively based on patient-reported outcome measures. For other symptoms of AR, both RFA and MAIT improved rhinorrhea significantly compared to baseline, with RFA also improving sneezing and nasal itching.

The reduction in inferior turbinate volume might reduce the amount and/or activity of reactive mucosa leading to improved symptoms of rhinorrhea, sneezing, and itching while preserving the physiologic functions of the mucosal epithelium (in mucosal-sparing techniques such as RFA).¹³ With RFA or submucosal diathermy, scar tissue develops in the submucosal layer causing damage to the vascular and glandular structures leading to fibrosis, prevention of regrowth, and a reduced amount of IgE and eosinophils present on the nasal mucosa.^{13,14} Additionally, relief in AR and NAR might be attributed to the destruction of branches of posterior nasal nerve, which plays an important role in

sneezing and hypersecretion.¹⁵ No statistical significance was observed when stratifying outcomes by AR and NAR groups, suggesting that the effectiveness of RFA in improving nasal obstruction is similar for both patient populations. A recent radiologic study showed no difference in the degree of ITH between patients with AR and NAR, further suggesting that improvements in nasal obstruction are likely similar for both groups.¹⁶

For the subset of studies that directly compared techniques, similar improvement in nasal obstruction was seen for patients treated with MAIT or RFA. A systematic review by Acevedo et al assessing outcomes on VAS nasal obstruction and physiologic measures of nasal patency also found similar results when comparing RFA and MAIT.¹⁷ In contrast, a systematic review by Mirza et al concluded that MAIT resulted in lower post-operative VAS nasal obstruction scores than RFA.¹⁸ Regarding the other techniques, we found that RFA achieved similar improvements in nasal obstruction when compared to electrocautery and turbinectomy/SMR. If techniques are indeed comparable, then factors driving choice of technique for ITR include

A. VAS Obstruction (0-10cm)



B. VAS Rhinorrhea (0-10cm)

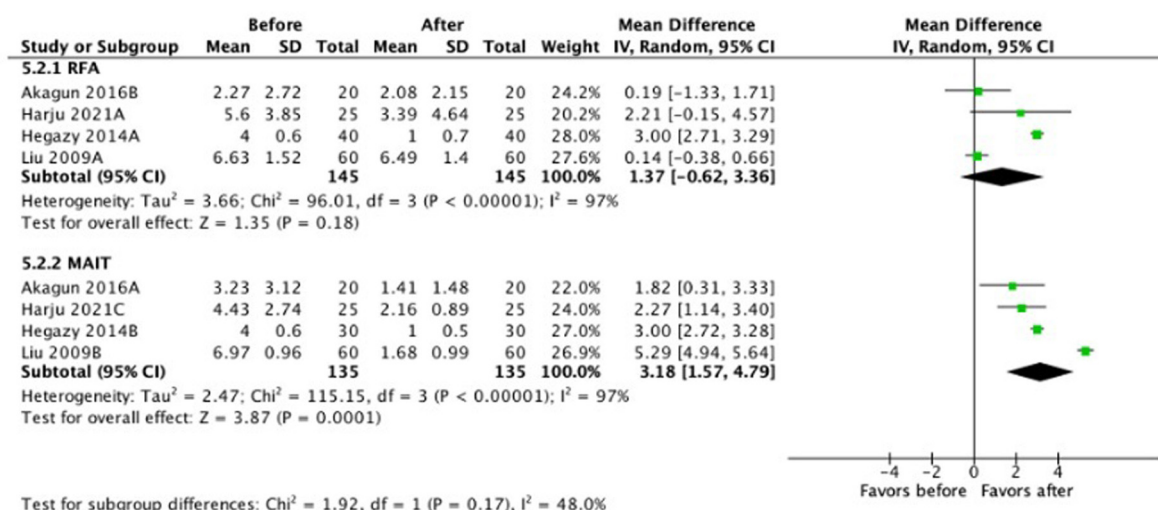


Figure 3. Mean difference between pre- and post-operative VAS results from studies directly comparing RFA to MAIT.

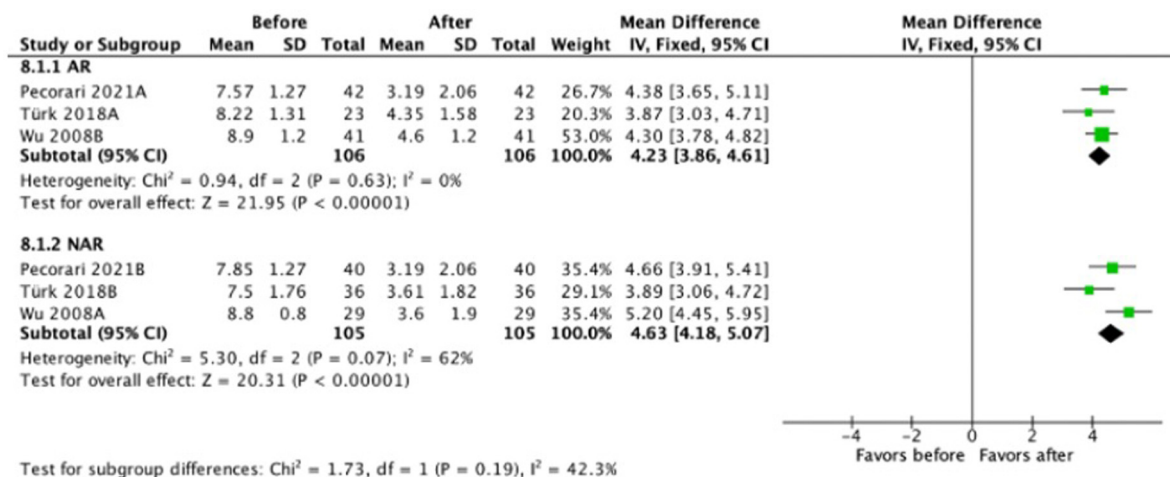
risks, length of procedures, and costs to the patient and health-care system. In absolute terms, MAIT demonstrate greatest improvements, but this did not reach significance. Further high-level comparative studies might increase power of comparisons.

Improvement in all physiologic measures of nasal patency including active anterior rhinomanometry (nasal resistance), acoustic rhinometry (nasal cavity volume), and nasal airflow was seen for RFA, MAIT, and laser. For SMR and electrocautery, not enough physiologic data was available. While statistically significant improvement was found for all physiologic measures, these changes might not be

clinically significant. For example, the MD was 0.78 for laser measured by AAR, and 0.40 for RFA measured by acoustic rhinometry, which are minimal changes when comparing pre- to post-operative measurements. The minimally clinically important difference (MCID), defined as the smallest change in outcomes that is meaningful to the patient, is typically used to assess whether these changes are clinically significant.¹⁹ However, MCID values have not been validated for acoustic rhinometry, active anterior rhinomanometry, or nasal airflow.¹⁹ While physiologic measures provide important clinical information regarding degree of nasal

Table 3. Mean Difference between pre- and postoperative VAS Obstruction from studies directly comparing RFA to Cautery and SMR/ Turbinectomy.

Technique	N studies (n patients)	Mean Difference [95%CI] VAS Obstruction	Baseline VAS weighted mean (SD)	Post op VAS weighted mean (SD)
RFA	5 (749)	3.81 [3.12, 4.50]	7.33 (0.89)◇	3.57 (0.75)
Cautery	5 (1288)	3.92 [3.57, 4.26]	7.62 (0.95)◇	3.67 (0.87)
RFA	3 (99)	4.13 [1.89, 6.38]	7.49 (1.11)	3.59 (1.48)
SMR	3 (97)	4.51 [2.29, 6.74]	7.64 (1.14)	3.45 (1.06)

◇ Comparison of weighted means showed baseline difference in VAS-obs $p < 0.05$ **Figure 4.** Forest plot of VAS obstruction outcomes after RFA in allergic rhinitis versus non-allergic rhinitis patients.

obstruction, patient-reported severity of nasal obstruction should complement these objective measures. To this point, patient-reported VAS nasal obstruction has been shown to significantly correlate with nasal airflow resistance measured by rhinomanometry.²⁰ However, other studies report a weak correlation between the minimal cross-sectional area or peak nasal inspiratory flow and VAS obstruction.^{21,22} Therefore, both patient-reported scores and physiologic measures of nasal patency should be examined when assessing treatment response.

Patient-reported scores were also analyzed by follow-up time. Both RFA and MAIT groups initially improved, but after 1-year, VAS obstruction scores worsened when compared to 3–6 months postoperatively (Figure 5). While both techniques are effective in reducing symptoms of nasal obstruction, these results suggest that peak effect following inferior turbinate reduction is achieved within the first year. Following the first year, there appears to be worsening of nasal congestion, however patients are still significantly improved relative to baseline. A possible mechanism for this is the regrowth of submucosal tissue that occurs over time after radiofrequency-induced fibrosis.²³ It is important

to note that the degree of worsening between 3–6 months and >1 year was small in absolute terms and may not be clinically significant (RFA increased by 0.66 points and MAIT by 0.85 points). Furthermore, the available data suggests that this decline in congestion scores stabilizes over time with longer follow-up after 1 year. A study examining RFA outcomes with mean follow-up of five years demonstrated sustained improvement in patient-reported symptoms including obstruction, with overall high ratings of patient satisfaction five years after surgery.²⁴ A similar study investigating outcomes following MAIT demonstrated improvement in nasal symptoms and a decrease in total nasal resistance measures with a mean follow-up of three years.²⁵

Since all techniques for ITR improved patient-reported and physiologic measures of nasal obstruction, the choice of treatment should also consider patient preference and appropriateness of an in-clinic versus operating room procedure. For example, more aggressive procedures including conventional turbinectomy are associated with greater risk of bleeding, crusting, pain, and a prolonged recovery period compared to mucosal-preservation techniques such

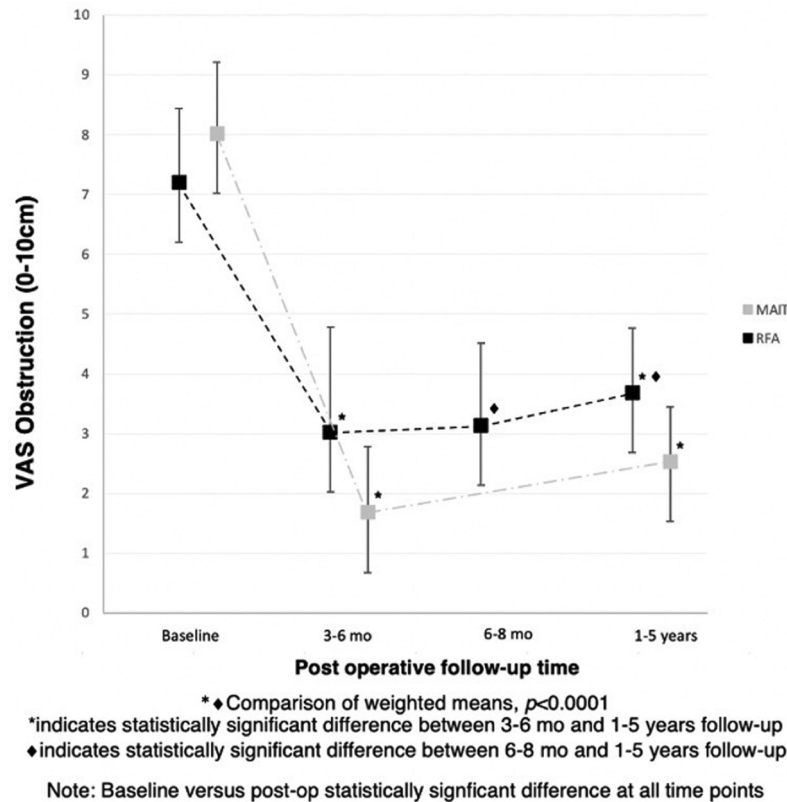


Figure 5. RFA and MAIT VAS obstruction results based on follow-up time.

as radiofrequency.²⁶ Finally, cost and resource availability also play a role in choice of technique.

Limitations and Future Directions

While the most reported outcome measure was obstruction, there were few studies reporting on other symptoms of rhinitis (rhinorrhea, sneezing, itching). Attention should be given to the other symptom domains to better assess the overall relief of symptom burden for patients with AR or NAR refractory to medication. While not the focus of this study, there were few studies reporting on patient-reported quality of life metrics such as Rhinoconjunctivitis Quality of Life Questionnaire (RQLQ) for patients before and after ITR surgery; future studies should consider employing such QOL questionnaires in addition to VAS ratings to assess the effect of different inferior turbinate surgery techniques on disease-specific quality of life.

Given the nature of this systematic review and meta-analysis, included studies often had significant heterogeneity in inclusion criteria, randomization techniques, and baseline characteristics. Therefore, results should be interpreted with caution and any head-to-head comparison between techniques warrants further study through randomized controlled trials. Additionally, simultaneous medical management may have impacted our findings. Turbinate reduction is typically

done after failure of medical therapy with appropriate nasal sprays, antihistamines, and immunotherapy. However, many studies do not explicitly define what medical management was given to patients before and after surgical treatment therefore this data was not extracted in our analysis. Future studies should assess the rate of postoperative complications such as crusting, bleeding, pain or the frequency with which patients required a revision surgery as these factors may also drive treatment decisions. While the purpose of this study was to investigate patient subjective and objective outcomes, economic considerations ultimately play a large role in real world decisions made by clinicians and patients. This analysis did not consider the costs and availability of resources associated with each surgical technique and is an area for further investigation.

Conclusion

Techniques for inferior turbinate reduction including RFA, MAIT, laser, electrocautery, and surgical submucosal resection all produce significant improvements in nasal airflow on both patient-reported and physiologic measures. RFA and MAIT yield comparable outcomes with durable long-term results. Peak benefit following ITR appears to be achieved within the first year, but significant benefits compared to baseline are achieved long-term.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article

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Supplemental Material

Supplemental material for this article is available online.

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