Comparison of nasal valve dysfunction treatment outcomes for temperature-controlled radiofrequency and functional rhinoplasty surgery: a systematic review and meta-analyses*

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Abstract

Background: Nasal valve dysfunction (NVD) is a substantial contributor to nasal airway obstruction. Minimally-invasive temperature-controlled radiofrequency (TCRF) treatment of the nasal valve is available and comparison with surgical techniques is warranted.

Methodology: Databases: Medline (PubMed), Embase, Cochrane Library. Population: adults with preprocedural nasal obstruction symptom evaluation (NOSE) score ≥45. Treatment effects were derived from a random effects model and reported as weighted mean difference in NOSE score between baseline; 3, 6, and 12 months postprocedure.

Results: Of 2529 initial articles, 5 studies describing TCRF treatment and 63 studies describing functional rhinoplasty were included. Pooled effect sizes for TCRF treatment and functional rhinoplasty were comparable in all analyses.

Conclusions: TCRF treatment of the internal nasal valve for NVD was associated with sustained effects comparable to functional rhinoplasty addressing the nasal valve only, rhinoplasty without concomitant turbinate treatment, and all rhinoplasty.

Key words: nasal airway obstruction, nasal valve, radiofrequency, rhinoplasty, nasal obstruction symptom evaluation (NOSE)

Introduction

Nasal valve dysfunction (NVD) is a common and often underdiagnosed cause of nasal airway obstruction (NAO) and is often discussed in the literature as nasal valve collapse [1,2]. Temperature-controlled radiofrequency (TCRF) device treatment of the internal nasal valve (NV) for the treatment of patients with NAO secondary to NVD is designed to tighten tissue within the submucosal layer of the lateral nasal wall, thereby stabilising the NV and decreasing the resistance to airflow. The minimally-invasive device treatment can be performed in an office setting and does not preclude subsequent surgical procedures. In a randomised controlled trial (RCT), TCRF treatment of NVD (both static and dynamic) resulted in a significantly greater reduction in NAO symptom burden than a sham control procedure [3], and single-arm studies have shown a sustained effect up to 4 years [4-10]. NVD may also be treated via functional rhinoplasty, including the use of spreader grafts (SGs), lateral crural strut grafts, butterfly grafts, and alar batten grafts, among a variety of other open and closed surgical techniques [11]. The objective of this systematic review and meta-analyses was to compare treatment effect sizes after TCRF treatment of the internal NV alone (i.e., not including turbinate treatment) and functional rhinoplasty surgery.

Materials and methods

General

Considering functional rhinoplasty treatment of NVD is often combined with septoplasty, turbinate treatment, and techniques to address cosmesis, a series of analyses were performed to compare TCRF treatment with (i) rhinoplasty surgery focused on the NV, (ii) rhinoplasty surgery without concomitant turbinate treatment, and (iii) all rhinoplasty surgery procedures. The treatment effect was determined from the nasal obstruction symptom evaluation (NOSE) scale scores at preprocedural baseline and follow-up [12]. Treatment effects at 3, 6, and 12 months postprocedure were derived. An average preprocedural NOSE score cutoff of 45 and higher was used to focus on patients with at least moderate NAO and objectively exclude patient populations focused on cosmetic outcomes alone. Moderate NAO is defined as a NOSE score ≥30 [13], however, a cutoff of ≥45 was chosen to maximise the potential that the majority of patients in a dataset exhibited at least moderate NAO based on an estimated lower confidence interval (CI) limit (e.g., 45 ± 21 in population of 10 patients is equivalent to 45 [95%CI, 30 to 60]).

Search strategy

A systematic review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines and checklist (Supplemental Table 1) using a patient, intervention, comparison, outcomes (PICO) framework (Supplemental Table 2). Medline (via PubMed), Embase, and the Cochrane Library databases were searched for articles published 2004 through December 05, 2022; a detailed search protocol including keywords is provided in the Supporting Information. In brief, database search strings included keywords 'rhinoplasty' and 'nasal obstruction' for a broad initial search. Systematic keyword searches were then used to (i) exclude irrelevant articles and articles not in English, (ii) categorise applicable articles, and (iii) identify articles reporting outcomes using the NOSE scale before subsequent abstract and full-text review.

Study selection

A complete list of eligibility criteria and additional information is available in Supplemental Table 3. Studies were included if they described TCRF treatment of the NV with the VivAer® device (Aerin Medical, USA) or all functional rhinoplasty procedures (primary or revision), with or without concomitant procedures including septoplasty and turbinate treatment. Descriptions of turbinate treatment in the original reports included inferior turbinate reduction (diathermy), in/out fracture, turbinoplasty, and turbinectomy – therefore, turbinate treatment is used as a collective term.

Key overall exclusion criteria were datasets with <10 patients at baseline; an average baseline NOSE score <45; use of a non-validated NOSE scale instrument (Supplemental Table 4); follow-up data with an average of <3 months or >12 months postprocedure; pediatric populations; datasets describing septoplasty only, reduction rhinoplasty, maxillary surgery (e.g., maxillary expan

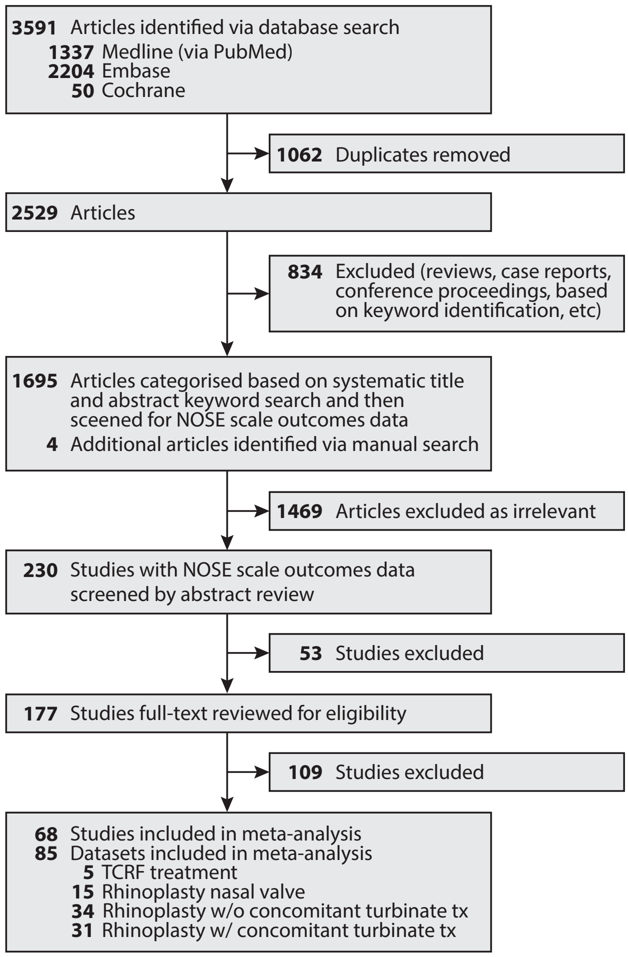
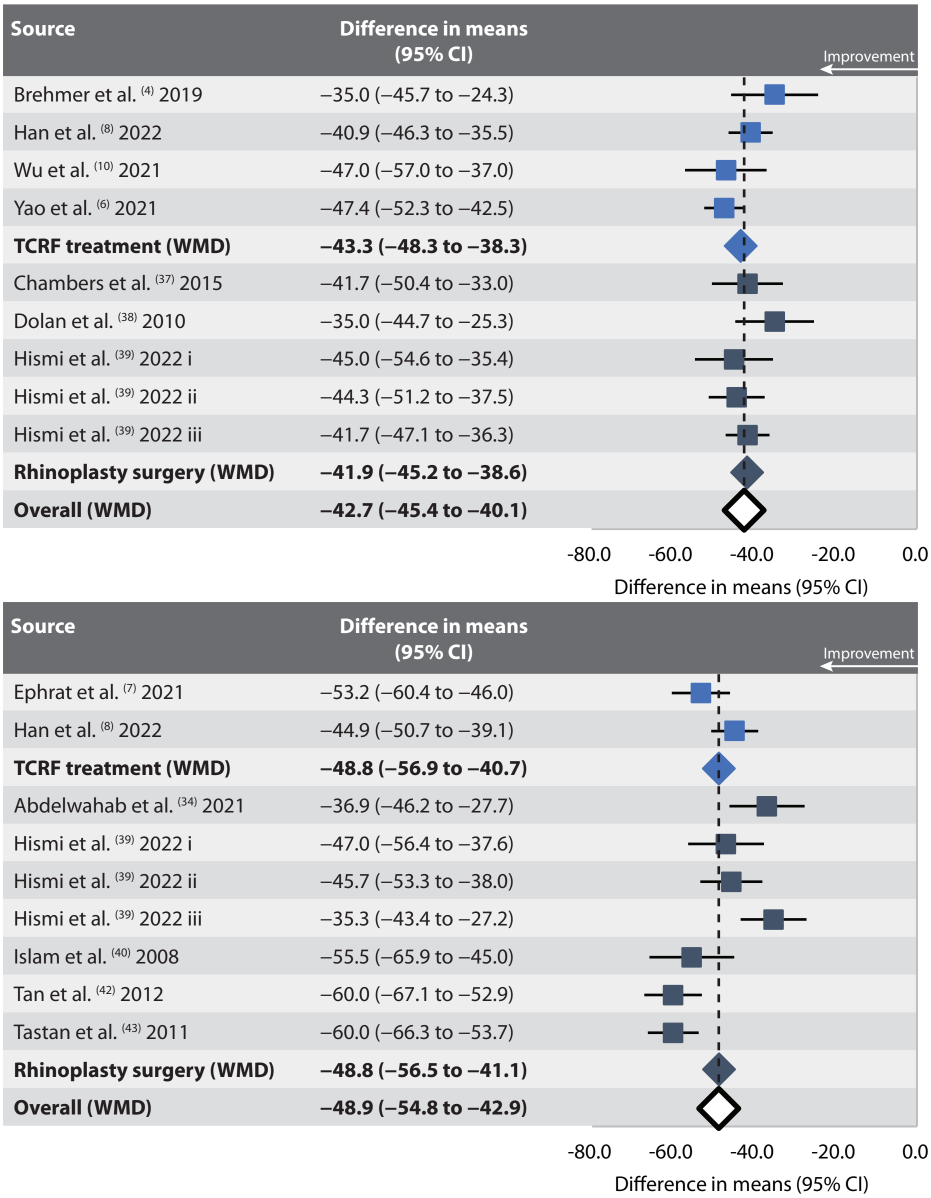


Figure 1. PRISMA study flow diagram. NOSE, nasal obstruction symptom evaluation; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-analyses.

-sion), maxillomandibular advancement, stents only, implants, caudal septal deviation treatment focus, or tip focus; and datasets with ambiguous NOSE score data or follow-up timeframe. With regard to the rationale for inclusion in the focused NV analyses, TCRF treatment with the VivAer device is a specific procedure targeting the internal NV to treat both static and dynamic NVD. Dynamic NVD is also termed lateral nasal wall insufficiency and NVD is described based on two zones, approximately corresponding to the internal NV and external NV regions [14]. Furthermore, Barham et al. noted that when making the structural components of the external NV more rigid, other components of the lateral nasal wall, such as the internal NV, may be affected [15]. Procedures focused on the middle vault, including the use of SGs, aim to increase the internal NV angle and increase air flow [16]. Therefore, studies including functional rhinoplasty procedures focused on the internal NV and/or the external NV and the middle vault were included in the analyses on NV treatment. Although TCRF may generally be used to treat turbinate hypertrophy, studies describing TCRF treatment with the VivAer device do not include turbinate treatment, and therefore analyses



Source	Difference in means (95% CI)
Brehmer et al. [4] 2019	−35.0 (−45.7 to −24.3)
Han et al. [8] 2022	−40.9 (−46.3 to −35.5)
Wu et al. [10] 2021	−47.0 (−57.0 to −37.0)
Yao et al. [6] 2021	−47.4 (−52.3 to −42.5)
TCRF treatment (WMD)	**−43.3 (−48.3 to −38.3)**
Chambers et al. [37] 2015	−41.7 (−50.4 to −33.0)
Dolan et al. [38] 2010	−35.0 (−44.7 to −25.3)
Hismi et al. [39] 2022 i	−45.0 (−54.6 to −35.4)
Hismi et al. [39] 2022 ii	−44.3 (−51.2 to −37.5)
Hismi et al. [39] 2022 iii	−41.7 (−47.1 to −36.3)
Rhinoplasty surgery (WMD)	**−41.9 (−45.2 to −38.6)**
Overall (WMD)	**−42.7 (−45.4 to −40.1)**

Source	Difference in means (95% CI)
Ephrat et al. [7] 2021	−53.2 (−60.4 to −46.0)
Han et al. [8] 2022	−44.9 (−50.7 to −39.1)
TCRF treatment (WMD)	**−48.8 (−56.9 to −40.7)**
Abdelwahab et al. [34] 2021	−36.9 (−46.2 to −27.7)
Hismi et al. [39] 2022 i	−47.0 (−56.4 to −37.6)
Hismi et al. [39] 2022 ii	−45.7 (−53.3 to −38.0)
Hismi et al. [39] 2022 iii	−35.3 (−43.4 to −27.2)
Islam et al. [40] 2008	−55.5 (−65.9 to −45.0)
Tan et al. [42] 2012	−60.0 (−67.1 to −52.9)
Tastan et al. [43] 2011	−60.0 (−66.3 to −53.7)
Rhinoplasty surgery (WMD)	**−48.8 (−56.5 to −41.1)**
Overall (WMD)	**−48.9 (−54.8 to −42.9)**

Figure 2. Forest plots of weighted mean differences in NOSE score between preprocedural baseline and 3 (above) and 12 months (below) for nasal valve treatment only analyses. NOSE, nasal obstruction symptom evaluation; WMD, weighted mean difference; 95% CI, 95% confidence interval.

including functional rhinoplasty without concomitant turbinate treatment were also performed.

Full texts were reviewed for eligibility by JP and confirmed by DL. Eligibility for the NV treatment and without concomitant turbinate treatment analyses was determined by JP and confirmed by MTY (NV) and DL (without concomitant turbinate treatment). All authors reviewed the list of eligible studies.

Data extraction

Article citation data, country, study design, population characteristics (age and sex), surgical technique(s), the number of patients in the study, and preprocedural and relevant follow-up NOSE score summary statistics were extracted for analysis. Data were extracted by JP and HO (acknowledgements). NOSE score data reported on more than one group in a study were extracted separately, resulting in more than one dataset for a single study in some cases. In other cases, several groups were reported in an article but only groups that met eligibility criteria were included.

Level of evidence assessment and MINORS score

Studies were assigned a level of evidence grade (described in Supplemental Table 5) and indexed by assignment of a methodological index for non-randomised studies (MINORS) score (JP and DL), with a global ideal score of 16 for non-comparative studies and 24 for comparative studies [17]. A score of ≤8 was considered poor quality, 9-14 moderate quality, and 15-16 good

Table 1. Dataset characteristics and intervention summaries.

Source	LoE, Design	No. [a]	%M:F [b]	Age, y [c]	Intervention summary [d]
Brehmer et al. [(4)] 2019, DE	4, P, NC	31	45:55	43 (11)	INV tx, TCRF treatment (VivAer)
Ephrat et al. [(7)] 2021, US	4, P, NC	39	49:51	52 (13)	INV tx, TCRF treatment (VivAer)
Han et al. [(8)] 2022, US	4, P, NC*	108	39:61	49 (12)	INV tx, TCRF treatment (VivAer)
Wu et al. [(10)] 2021, US	4, P, NC	18	67:33	46 (17)	INV tx, TCRF treatment (VivAer)
Yao et al. [(6)] 2021, US	4, P, NC	122	48:53	50 (16)	INV tx, TCRF treatment (VivAer)
Nasal valve surgery [e]					
Abdelwahab et al. [(34)] 2021, US	4, R, NC#	59	-	-	LCSG group
Aladag et al. [(35)] 2019, TK	4, R, NC	32	66:34	35 (12)	Modified splay graft
Burks et al. [(36)] 2022 i, US	2, P, C	113	50:50	37 (15)	SG w/ dorsal hump reduction
Burks et al. [(36)] 2022 ii, US	2, P, C	113	71:29	29 (12)	SG w/o dorsal hump reduction
Chambers et al. [(37)] 2015, US	4, P, NC	40	57:43	39 (-)	NV tx by grafts after failed SP
Dolan et al. [(38)] 2010, US	4, P, NC	24	76:24	49 (-)	NV tx, caudal upper lateral cartilage
Hismi et al. [(39)] 2022 i, US	2, P, C	75	47:53	40 (14)	SG + alar rim graft
Hismi et al. [(39)] 2022 ii, US	2, P, C	109	-:-	46 (15)	SG + LCSG
Hismi et al. [(39)] 2022 iii, US	2, P, C	162	-:-	33 (13)	SG alone
Islam et al. [(40)] 2008, TK	4, P, NC	11	45:55	35 (-)	Modified splay graft, endonasal
Palesy et al. [(41)] 2015, AU	4, P, NC	19	32:68	33 (12)	ENV tx, primary and revision
Tan et al. [(42)] 2012, CA	4, P, NC	15	47:53	46 (-)	ENV lateral crural J-flap repair
Tastan et al. [(43)] 2011, TK	4, P, NC	19	58:42	- (-)	INV tx H-graft technique
Weitzman et al. [(44)] 2021 i, US	2, P, C	276	52:48	35 (15)	SG + mix of grafts
Weitzman et al. [(44)] 2021 ii, US	2, P, C	41	54:46	43 (16)	Extended SG + mix of grafts
Functional rhinoplasty – without concomitant turbinate treatment [f]					
Albergo et al. [(45)] 2020, AR	4, R, NC	33	85:15	32 (12)	SG in severe SD
Andrews et al. [(46)] 2015, GB	4, P, NC#	121	64:36	34 (12)	Septorhinoplasty
Başer et al. [(47)] 2016, TK	4, R, NC	45	64:36	32 (31)	Septorhinoplasty, open
Datema et al. [(48)] 2017, NL	4, P, NC	97	54:46	35 (-)	Rhinoplasty
de Moura et al. [(30)] 2018 ii, BR	1, P, RAN	21	44:56	36 (16)	Mix of grafts, w/o turbinate tx
Fuller et al. [(49)] 2017, US	4, P, NC	135	56:44	37 (15)	Rhinoseptoplasty: mix of grafts
Fuller et al. [(50)] 2017, US	4, R, NC	62	51:49	34 (16)	PD plates for L-strut support, grafts
Fuller et al. [(51)] 2019, US	4, P, NC	154	47:53	37 (15)	Mix of grafts
Fuller et al. [(52)] 2019, US	4, P, NC	281	43:57	36 (16)	Mix of grafts
Gökçe Kütük et al. [(53)] 2019, TK	4, P, NC#	90	36:64	27 (7)	Rhinoplasty, open and closed
Gökçe Kütük et al. [(54)] 2022, TK	4, P, NC	51	35:65	28 (6)	Rhinoplasty
Goudakos et al. [(55)] 2017, GR	4, R, NC	46	37:63	35 (-)	Revision rhinoplasty
Günel et al. [(56)] 2015 i, TK	2, P, C	57	62:38	24 (5)	Septorhinoplasty, primary
Günel et al. [(56)] 2015 ii, TK	2, P, C	22	-:-	- (-)	Septorhinoplasty, secondary
Hismi et al. [(57)] 2020, US	4, P, NC#	122	48:52	38 (16)	Mix of grafts
Justicz et al. [(58)] 2019 i, US	3, P, C	18	-:-	44 (15)	Mix of grafts, homologous cartilage
Justicz et al. [(58)] 2019 ii, US	3, P, C	80	-:-	- (-)	Mix of grafts, autologous cartilage
Kandathil et al. [(59)] 2021, US	4, P, NC	99	59:41	40 (15)	Rhinoplasty
Kandathil et al. [(60)] 2021, US	4, R, NC	90	60:40	39 (15)	Rhinoplasty
Kaura et al. [(61)] 2019, GB	4, P, NC	69	63:37	34 (-)	External septorhinoplasty, SP
Lavinsky-Wolff et al. [(29)] 2013 ii, BR	1, P, RAN	24	52:48	32 (15)	Rhinoplasty w/o turbinate tx group
Lindsay et al. [(62)] 2012 i, US	2, P, C	30	72:28	40 (-)	INV and ENV tx, mix of grafts, SP
Lindsay et al. [(62)] 2012 ii, US	2, P, C	14	-:-	- (-)	INV tx, SG w/ flaring suture, SP

Source	LoE, Design	No. [a]	%M:F [b]	Age, y [c]	Intervention summary [d]
Lindsay et al. [62] 2012 iii, US	2, P, C	16	-:-	- (-)	ENV tx , LCSG, SP
Nural et al. [63] 2019, TK	4, R, NC	63	35:35	30 (9)	Crooked nose tx (group 1)
Pecorari et al. [64] 2017, IT	4, P, NC#	15	47:53	38 (11)	Rhinoplasty, closed, SP
Radulesco et al. [65] 2018, FR	4, P, NC	35	37:63	32 (-)	Mix of grafts, SP
Sahin et al. [66] 2016, TK	4, P, NC	22	59:41	21 (2)	Modified triangular SG
Shafik et al. [67] 2020, EG	4, P, NC	20	70:30	22 (3)	Rhinoplasty
Tugrul et al. [68] 2019, TK	4, R, NC	28	-:-	28 (4)	Septorhinoplasty
van Zijl et al. [69] 2022, NL	4, P, NC	357	51:49	36 (-)	Rhinoplasty
Weitzman et al. [70] 2022 i, US	2, P, C	315	52:48	35 (15)	SG w/ ULC release
Weitzman et al. [70] 2022 ii, US	2, P, C	10	60:40	35 (15)	SG w/o ULC release
Yamasaki et al. [28] 2019 i, US	2, P, C	347	46:54	36 (16)	Mix of grafts, SP
Functional rhinoplasty – with concomitant turbinate treatment [g]					
Alan et al. [71] 2022 i, TK	2, P, C	19	47:53	23 (4)	SG, structural group, SP
Alan et al. [71] 2022 ii, TK	2, P, C	15	53:47	24 (7)	SG, preservation group, SP
Andrews et al. [46] 2021, US	4, R, NC	216	75:24	34 (-)	Septorhinoplasty
Barham et al. [15] 2015, AU	4, P, NC#	41	41:59	- (-)	ENV tx, primary and revision
Bessler et al. [72] 2015, CH	4, R, NC	43	65:35	30 (-)	Anterior spreader flap, SP
Calloway et al. [73] 2019, US	4, R, NC	90	31:69	38 (-)	Articulated ARG, mix of grafts
de Moura et al. [30] 2018 i, BR	1, P, RAN	23	56:44	36 (13)	Mix of grafts, w/ turbinate tx
Eren et al. [74] 2014, TK	4, P, NC	15	53:47	32 (6)	Autospreading spring flap, SP
Erickson et al. [75] 2016, CA	4, P, NC	17	94:6	35 (12)	Endonasal SG, SP
Gerecci et al. [76] 2019, US	4, P, NC	49	35:65	44 (14)	Mix of grafts, SP
Inan et al. [77] 2022 i, TK	3, R, C	57	34:66	27 (9)	Septorhinoplasty, extensive MT
Inan et al. [77] 2022 ii, TK	3, R, C	62	-:-	27 (9)	Septorhinoplasty, normal MT
Inan et al. [78] 2022, TK	4, P, NC	97	25:75	27 (8)	Rhinoplasty
Lavinsky-Wolff et al. [29] 2013 i, BR	1, P, RAN	25	32:68	32 (12)	Rhinoplasty w/ turbinate tx group
Loyo et al. [79] 2016, US	4, R, NC	19	32:68	46 (19)	Modified butterfly graft
Martin et al. [80] 2022, DE	4, P, NC#	52	59:41	30 (-)	Septorhinoplasty group
Most et al. [81] 2006, US	4, P, NC#	41	66:34	42 (-)	INV SG, ENV orbital rim sutures, SP
Rhee et al. [82] 2005, US	4, P, NC	20	15:85	34 (-)	Mix of grafts, SP
Rudes et al. [83] 2018, DE	4, P, NC	122	39:62	32 (13)	Mix of grafts, SP
Şahin et al. [84] 2022 i, TK	2, P, C	40	50:50	29 (9)	SG for middle vault
Şahin et al. [84] 2022 ii, TK	2, P, C	26	58:42	33 (9)	L-strut graft for middle vault
Sowder et al. [85] 2017 i, US	3, R, C	20	-:-	- (-)	Spreader flap w/o DH tx, SP
Sowder et al. [85] 2017 ii, US	3, R, C	24	-:-	- (-)	SG w/o DH tx, SP
Taha et al. [86] 2021 i, US	2, P, C	10	60:40	40 (6)	ENV tx with LCSG - primary
Taha et al. [86] 2021 ii, US	2, P, C	16	62:38	41 (13)	ENV tx with LCSG - revision
Tjahjono et al. [87] 2019, AU	4, P, NC	144	41:59	38 (13)	Septorhinoplasty
Vaezeafshar et al. [88] 2018, US	4, R, NC#	44	18:82	46 (16)	Mix of grafts, SP
Yamasaki et al. [28] 2019 ii, US	2, P, C	166	50:50	36 (14)	Mix of grafts, SP
Yamasaki et al. [89] 2020, US	4, P, NC	495	47:53	36 (16)	Mix of grafts, SP
Yeung et al. [90] 2016, US	4, P, NC	79	48:52	36 (14)	SG, alar batten graft, SP
Yoo et al. [91] 2011, US	4, P, NC	17	-:-	- (-)	Autospreader flap, sutures, SP

Source country 2-letter abbreviations: AR, Argentina; AU, Australia; BR, Brazil; CA, Canada; EG, Egypt; GB, England; GR, Greece; IT, Italy; NL, The Netherlands; CH, Switzerland; TK, Turkey; US, United States of America. **Study design abbreviations**: P, prospective; R, retrospective. C, comparative; NC, non-comparative; NC*, single arm of all active treatment patients after primary endpoint of randomised sham procedure-controlled trial; NC#, single dataset extracted from a study including additional comparative groups that were ineligible for inclusion/a single dataset was extracted

(Supplemental Table 6 and Supplemental Table 7 for additional information); RAN, randomised. **Intervention abbreviations**: ARG, alar rim graft; DH, dorsal hump; ENV, external nasal valve; INV, internal nasal valve; LCSG, lateral crural strut graft; MT, middle turbinate; PD, polydioxanone; SD, septal deviation; SG, spreader graft; SP, septoplasty; TCRF, temperature-controlled radiofrequency; tx, treatment; ULC, upper lateral cartilage; w/, with; w/o, without.

[a] Number of patients with a NOSE score at preprocedural baseline. [b] Percentage of male:female, if reported in the original report. Sex data may be on a larger number of patients than the number of patients with a NOSE score at preprocedural baseline and/or may be on the whole population rather than groups in the study based on reporting methods in the original report. Additional details are available in Supplemental Table 6. [c] Mean ± standard deviation in years, if reported in the original report. Age data may be on a larger number of patients than the number of patients with a NOSE score at preprocedural baseline and/or may be on the whole population rather than groups in the study based on reporting methods in the original report. Additional information is available in Supplemental Table 6. [d] Brief description of interventions affecting the nasal valve and/or study focus. Additional information is available in Supplemental Table 6. [e] Included in all analyses. [f] Also included in the 'functional rhinoplasty surgery without concomitant turbinate treatment' analyses. [g] Also included in the 'all functional rhinoplasty surgery procedures' analyses.

Table 2. Meta-analyses results summary – weighted mean differences in NOSE score between preprocedural baseline and follow-up.

Analysis	3 months			6 months			12 months		
	N/n [a]	WMD (95% CI) [b]	I^2 [c]	N/n [a]	WMD (95% CI) [b]	I^2 [c]	N/n [a]	WMD (95% CI) [b]	I^2 [c]
Nasal valve treatment									
TCRF	4/275	−43.3 (−48.3 to −38.3)	51.5%	2/139	−49.3 (−61.8 to −36.7)	86.7%	2/124	−48.8 (−56.9 to −40.7)	67.9%
Rhinoplasty	5/255	−41.9 (−45.2 to −38.6)	0.0%	9/739	−40.4 (−47.5 to −33.3)	93.8%	7/232	−48.8 (−56.5 to −41.1)	85.1%
Combined	9/530	−42.7 (−45.4 to −40.1)	17.7%	11/878	−42.1 (−48.4 to −35.8)	92.8%	9/356	−48.9 (−54.8 to −42.9)	81.8%
Without turbinate treatment									
TCRF	4/275	−43.3 (−48.3 to −38.3)	51.5%	2/139	−49.3 (−61.8 to −36.7)	86.7%	2/124	−48.8 (−56.9 to −40.7)	67.9%
Rhinoplasty	18/1088	−44.4 (−48.9 to −39.9)	92.0%	31/2151	−43.4 (−46.6 to −40.3)	90.7%	21/945	−45.3 (−49.1 to −41.4)	80.9%
Combined	22/1363	−44.1 (−48.0 to −40.3)	90.3%	33/2290	−43.8 (−46.9 to −40.8)	90.4%	23/1069	−45.6 (−49.1 to −42.1)	80.2%
All									
TCRF	4/275	−43.3 (−48.3 to −38.3)	51.5%	2/139	−49.3 (−61.8 to −36.7)	86.7%	2/124	−48.8 (−56.9 to −40.7)	67.9%
Rhinoplasty	33/2158	−47.1 (−50.4 to −43.8)	92.0%	41/2928	−42.9 (−45.8 to −40.0)	91.1%	36/1460	−47.7 (−51.1 to −44.4)	90.0%
Combined [d]	37/2433	−46.6 (−49.6 to −43.6)	91.2%	43/3067	−43.2 (−46.0 to −40.4)	90.9%	38/1584	−47.8 (−51.0 to −44.6)	89.5%

[a] N = number of datasets. n = number of patients at the follow-up timepoint. [b] Weighted mean difference (WMD) in nasal obstruction symptom evaluation (NOSE) score between baseline and follow-up with 95% confidence interval. Weights are from random-effects model. [c] Confidence intervals are listed in Supplemental Table 10. [d] Dataset evaluated for publication bias via Egger's test.

quality for non-comparative studies. Cutoffs were ≤14, 15-22, and 23-24, respectively, for comparative studies.

Statistical analysis

All statistical analyses were performed using R Statistical Software (v41.2; R Core Team 2021). Meta-analysis was conducted via the meta package (v6.2.1) [(18,19)]. The treatment effects and CIs are presented in forest plots using data exported from the meta package into Microsoft Excel. When possible, the meta-analyses used statistics directly as described in the source, however some assumptions were made to utilise the median when a mean was not published and computational estimates were made to obtain study variability when not directly accessible (from CI, interquartile range [IQR], etc.). For analysis purposes, treatment effects were defined as the weighted mean difference (WMD) in NOSE score from baseline to follow-up timepoint and a random-effects model was used. The I^2 statistic was used to assess statistical heterogeneity by applying thresholds suggesting low (30%), moderate (60%), and considerable (≥75%) heterogeneity among studies [(20,21)]. No indications of publication bias were found using Egger's test in the combined meta-analyses of TCRF and rhinoplasty studies at baseline or when evaluating the WMDs at each follow-up timepoint. Due to heterogeneity in the rhinoplasty data sources and for comparability purposes, a random-effects model is used for analysis purposes throughout.

Results

The initial database search yielded 2529 records after initial duplicate removal. After full-text review, 68 studies with 85 datasets (6519 patients at preprocedural baseline) were included in

Source	Difference in means (95% CI)
Brehmer et al. [4] 2019	−35.0 (−45.7 to −24.3)
Han et al. [8] 2022	−40.9 (−46.3 to −35.5)
Wu et al. [10] 2021	−47.0 (−57.0 to −37.0)
Yao et al. [6] 2021	−47.4 (−52.3 to −42.5)
TCRF treatment (WMD)	**−43.3 (−48.3 to −38.3)**
Chambers et al. [37] 2015	−41.7 (−50.4 to −33.0)
Dolan et al. [38] 2010	−35.0 (−44.7 to −25.3)
Hismi et al. [39] 2022 i	−45.0 (−54.6 to −35.4)
Hismi et al. [39] 2022 ii	−44.3 (−51.2 to −37.5)
Hismi et al. [39] 2022 iii	−41.7 (−47.1 to −36.3)
Andrews et al. [92] 2015	−37.5 (−43.9 to −31.1)
Datema et al. [48] 2017	−37.2 (−43.0 to −31.4)
de Moura et al. [30] 2018 ii	−56.8 (−69.3 to −44.3)
Gökçe Kütük et al. [53] 2019 i	−58.3 (−62.2 to −54.4)
Gökçe Kütük et al. [54] 2022 ii	−63.9 (−69.0 to −58.8)
Günel et al. [56] 2015 i	−37.9 (−48.5 to −27.4)
Günel et al. [56] 2015 ii	−29.6 (−42.3 to −16.8)
Kandathil et al. [59] 2021	−52.0 (−57.4 to −46.6)
Kandathil et al. [60] 2021	−49.3 (−55.3 to −43.3)
Lavinsky-Wolff et al. [29] 2013 ii	−52.0 (−62.9 to −41.1)
Sahin et al. [66] 2016	−46.4 (−51.4 to −41.3)
Shafik et al. [67] 2020	−28.5 (−33.0 to −24.0)
Yamasaki et al. [28] 2019	−39.4 (−41.5 to −37.3)
Alan et al. [71] 2022 i	−55.7 (−67.2 to −44.2)
Alan et al. [71] 2022 ii	−59.3 (−69.9 to −48.7)
Andrews et al. [46] 2021	−50.7 (−54.1 to −47.3)
de Moura et al. [30] 2018 i	−47.9 (−61.2 to −34.6)
Erickson et al. [75] 2016	−31.5 (−46.5 to −16.5)
Gerecci et al. [76] 2019	−50.8 (−58.0 to −43.6)
Inan et al. [77] 2022 i	−65.9 (−69.8 to −62.0)
Inan et al. [77] 2022 ii	−60.4 (−64.3 to −56.5)
İnan et al. [78] 2022	−41.5 (−46.4 to −36.6)
Lavinsky-Wolff et al. [29] 2013 i	−46.6 (−59.8 to −33.4)
Rhee et al. [82] 2005	−48.2 (−61.9 to −34.5)
Vaezeafshar et al. [88] 2018	−45.3 (−56.6 to −34.0)
Yamasaki et al. [28] 2019	−50.1 (−52.4 to −47.8)
Yamasaki et al. [89] 2020	−45.3 (−48.5 to −42.1)
Yeung et al. [90] 2016	−48.6 (−56.6 to −40.6)
Rhinoplasty surgery (WMD)	**−47.1 (−50.4 to −43.8)**
Overall (WMD)	**−46.6 (−49.6 to −43.6)**

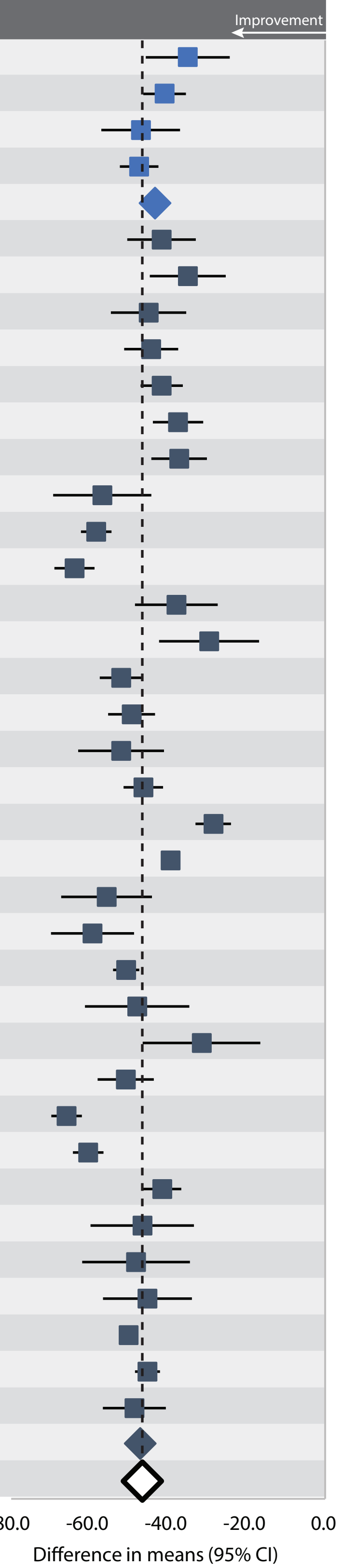


Figure 3. A) Forest plot of weighted mean differences in NOSE score between preprocedural baseline and 3 months for all procedures analysis. NOSE, nasal obstruction symptom evaluation; WMD, weighted mean difference; 95% CI, 95% confidence interval.

Source	Difference in means (95% CI)
Ephrat et al. [7] 2021	−53.2 (−60.4 to −46.0)
Han et al. [8] 2022	−44.9 (−50.7 to −39.1)
TCRF treatment (WMD)	**−48.8 (−56.9 to −40.7)**
Abdelwahab et al. [34] 2021	−36.9 (−46.2 to −27.7)
Hismi et al. [39] 2022 i	−47.0 (−56.4 to −37.6)
Hismi et al. [39] 2022 ii	−45.7 (−53.3 to −38.0)
Hismi et al. [39] 2022 ii	−35.3 (−43.4 to −27.2)
Islam et al. [40] 2008	−55.5 (−65.9 to −45.0)
Tan et al. [42] 2012	−60.0 (−67.1 to −52.9)
Tastan et al. [43] 2011	−60.0 (−66.3 to −53.7)
Albergo et al. [45] 2020	−49.1 (−57.4 to −40.8)
Başer et al. [47] 2016	−61.1 (−69.1 to −53.1)
Datema et al. [48] 2017	−38.0 (−44.8 to −31.2)
Fuller et al. [50] 2017	−42.1 (−55.3 to −28.9)
Goudakos et al. [55] 2017	−40.0 (−46.6 to −33.4)
Hismi et al. [57] 2020	−37.2 (−52.4 to −22.0)
Justicz et al. [58] 2019 i	−30.9 (−64.6 to 2.8)
Justicz et al. [58] 2019 ii	−36.2 (−47.3 to −25.1)
Kandathil et al. [59] 2021	−44.0 (−54.3 to −33.7)
Kandathil et al. [60] 2021	−39.5 (−51.2 to −27.8)
Radulesco et al. [65] 2018	−50.5 (−60.4 to −40.6)
Tugrul et al. [68] 2019	−45.0 (−54.4 to −35.6)
van Zijl et al. [69] 2022	−43.4 (−47.4 to −39.4)
Yamasaki et al. [28] 2019	−37.3 (−40.3 to −34.3)
Alan et al. [71] 2022 i	−55.2 (−66.2 to −44.2)
Alan et al. [71] 2022 ii	−60.7 (−70.7 to −50.7)
Barham et al. [15] 2015	−30.3 (−40.3 to −20.2)
Bessler et al. [72] 2015	−54.4 (−58.6 to −50.2)
Eren et al. [74] 2014	−57.3 (−65.6 to −49.0)
Loyo et al. [79] 2016	−46.6 (−60.8 to −32.4)
Şahin et al. [84] 2022 i	−51.7 (−60.1 to −43.3)
Şahin et al. [84] 2022 ii	−71.8 (−75.7 to −67.9)
Sowder et al. [85] 2017 i	−63.4 (−77.0 to −49.8)
Sowder et al. [85] 2017 ii	−58.5 (−70.3 to −46.7)
Taha et al. [86] 2021 i	−42.8 (−48.2 to −37.4)
Taha et al. [86] 2021 ii	−31.3 (−46.8 to −15.7)
Vaezeafshar et al. [88] 2018	−44.7 (−53.0 to −36.4)
Yamasaki et al. [28] 2019	−52.7 (−55.2 to −50.2)
Yamasaki et al. [89] 2020	−41.3 (−45.8 to −36.8)
Rhinoplasty surgery (WMD)	**−47.7 (−51.1 to −44.4)**
Overall (WMD)	**−47.8 (−51.0 to −44.6)**

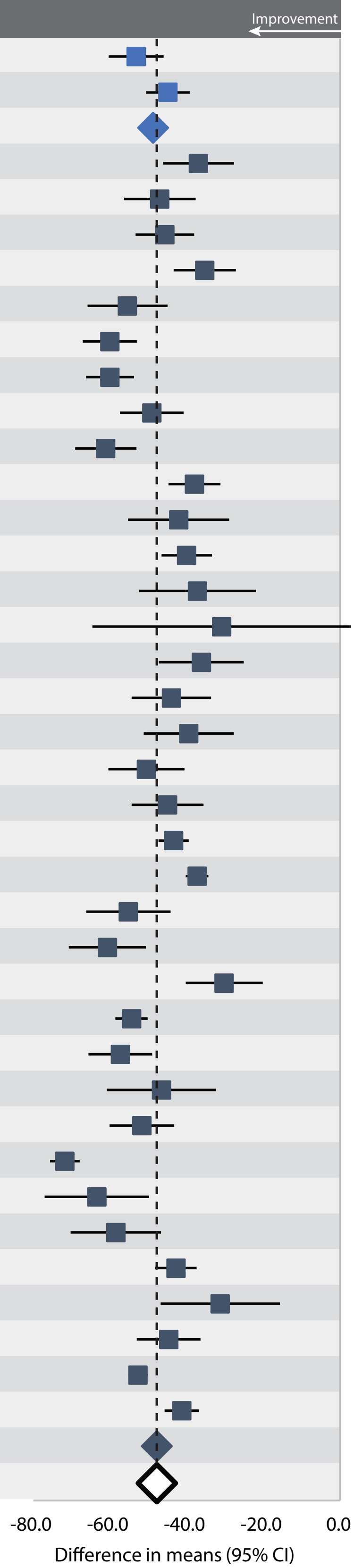


Figure 3. B) Forest plot of weighted mean differences in NOSE score between preprocedural baseline and 12 months for all procedures analysis. NOSE, nasal obstruction symptom evaluation; WMD, weighted mean difference; 95% CI, 95% confidence interval.

the meta-analyses (Figure 1), of which 5 datasets described TCRF treatment and 80 described functional rhinoplasty. The studies/datasets are summarised in Table 1 with additional information in Supplemental Table 6 through Supplemental Table 9. Study characteristics including study design, sample size, location, and follow-up duration are summarised in Supplemental Table 8 and Supplemental Table 9. The datasets included a total of 6519 patients with preprocedural baseline NOSE score: 318 for TCRF treatment and 6201 for all functional rhinoplasty surgery procedures. The median number of patients per dataset was 43 (IQR, 21 to 99). The mean age of study populations ranged from 21.4 to 51.7 years with a distribution of 50.9% and 49.1% for male and female patients, respectively, based on demographics datasets (Supplemental Table 6 and Supplemental Table 8).

TCRF treatment and nasal valve surgery

The treatment effects for TCRF treatment and NV surgery were comparable at 3 months: WMD, −43.3 (95%CI, −48.3 to −38.3), I^2=51.5% for TCRF treatment and WMD, −41.9 (95%CI, −45.2 to −38.6), I^2=0.0% for functional rhinoplasty (Table 2 and Figure 2). The treatment effect was equally durable for both treatment methods, as evidenced by the comparable effects in each group at each timepoint and when comparing the results temporally at 3, 6, and 12 months (Table 2). At 12 months, WMD, −48.8 (95%CI, −56.9 to −40.7), I^2=67.9% for TCRF treatment and WMD, −48.8 (95%CI, −56.5 to −41.1), I^2=85.1% for functional rhinoplasty (Table 2). Forest plots of all timepoints are shown in Supplemental Figure 1. The overall WMDs (TCRF treatment and functional rhinoplasty combined) were −42.7 (95%CI, −45.4 to −40.1) at 3 months and −48.9 (95%CI, −54.8 to −42.9) at 12 months (Table 2 and Figure 2).

TCRF treatment and functional rhinoplasty surgery without concomitant turbinate treatment

The treatment effects for TCRF treatment and functional rhinoplasty surgery without concomitant turbinate treatment were comparable at 3 months: WMD, −43.3 (95%CI, −48.3 to −38.3), I^2=51.5% for TCRF treatment and WMD, −44.4 (95%CI, −48.9 to −39.9), I^2=92.0% for functional rhinoplasty (Table 2 and Supplemental Figure 2). The treatment effect was equally durable for both treatment methods, as evidenced by the comparable effects in each group at each timepoint and when comparing the results temporally at 3, 6, and 12 months (Table 2). At 12 months, WMD, −48.8 (95%CI, −56.9 to −40.7), I^2=67.9% for TCRF treatment and WMD, −45.3 (95%CI, −49.1 to −41.4), I^2=80.9% for functional rhinoplasty without concomitant turbinate treatment (Table 2). Forest plots of all timepoints are shown in Supplemental Figure 2. The overall WMDs (TCRF treatment and functional rhinoplasty combined) were −44.1 (95%CI, −48.0 to −40.3) at 3 months and −45.6 (95%CI, −49.1 to −42.1) at 12 months (Table 2).

TCRF treatment and all functional rhinoplasty surgery procedures

The treatment effects for TCRF treatment and all functional rhinoplasty surgery were comparable at 3 months: WMD, −43.3 (95%CI, −48.3 to −38.3),I^2=51.5% for TCRF treatment and WMD, −47.1 (95%CI, −50.4 to −43.8), I^2=92.0% for functional rhinoplasty (Table 2 and Figure 3). The treatment effect was equally durable for both treatment methods, as evidenced by the comparable effects in each group at each timepoint and when comparing the results temporally at 3, 6, and 12 months (Table 2). At 12 months, WMD, −48.8 (95%CI, −56.9 to −40.7), I^2=67.9% for TCRF treatment and WMD, −47.7 (95%CI, −51.1 to −44.4), I^2=90.0% for functional rhinoplasty (Table 2). Forest plots of all timepoints are shown in Supplemental Figure 3. The overall WMDs (TCRF treatment and functional rhinoplasty combined) were −46.6 (95%CI, −49.6 to −43.6) at 3 months and −47.8 (95%CI, −51.0 to −44.6) at 12 months (Table 2 and Figure 3).

Study design, data quality, level of evidence

Of the 68 studies, 54 (76.5%) were prospective and 16 (23.5%) were retrospective; 63 (92.6%) were single center and 5 (7.4%) were multicenter (Table 1, Supplemental Table 7, Supplemental Table 9). Fifty-two (76.5%) studies were non-comparative, 13 (19.1%) were comparative (2 [2.9%] randomised), and 1 (1.5%) TCRF treatment dataset was the longitudinal analysis of a single cohort combining the index active treatment and crossover arms after the 3-month primary endpoint of an RCT (Table 1, Supplemental Table 7, Supplemental Table 9). Overall, the studies were moderate to poor quality based on MINORS score (Supplemental Table 7, Supplemental Table 9). For the 53 non-comparative studies, 8 (15.1%) were poor quality and 45 (84.9%) were moderate quality, with an overall median MINORS score of 10 (IQR, 9 to 11). For the 15 comparative studies, 11 (73.3%) were poor quality, 3 (20.0%) were moderate quality, and 1 (6.7%) was good quality, with an overall median MINORS score of 13 (IQR, 12 to 15) (Supplemental Table 9). The median level of evidence grade was 4 (IQR, 4 to 4) (Table 1, Supplemental Table 7, Supplemental Table 9).

Discussion

The results of our systematic review and meta-analyses showed outcomes for TCRF treatment of the internal NV were comparable to functional rhinoplasty in terms of effect size and durability through 12 months. As evidenced by the datasets included, functional rhinoplasty for the treatment of NAO covers a wide range of procedures and techniques, typically focused on addressing the internal NV in order to improve nasal airflow. The minimal differences in treatment effect in the different analyses comparing TCRF treatment to functional rhinoplasty surgical procedures suggest that TCRF treatment represents an effective approach of treatment NVD by addressing the internal

NV. Furthermore, these results suggest that TCRF treatment represents a durable and effective minimally-invasive alternative to surgery for many NVD patients. Given the variety of surgical techniques, meta-analyses of published data are the most accessible method to compare approaches as enrollment in a direct comparative design would be impractical. However, the wide variety of included studies and techniques also resulted in high heterogeneity scores with the included studies being of moderate to poor quality due to many factors – both of which must be taken into account when interpreting the outcomes of these meta-analyses.

As with any procedure, patient selection is important. With a new technique, patient selection for TCRF treatment may not be as familiar as compared to established surgical procedures. To date, TCRF treatment data are based on prospective studies and eligibility criteria defined the patient populations. The eligibility criteria of the TCRF studies are included in each individual report, however, generally included that NVD should be the primary or significant contributor to the patient's NAO as determined by the study investigator. Furthermore, patients had to demonstrate response to temporary nasal valve elevation and stabilization (e.g., the use of external dilator strips or the Cottle manoeuvre). While patient characteristics that may be more amenable to TCRF treatment success continue to be investigated and determined, thus far, studies have shown no differences in the outcomes of patients with or without prior nasal surgery [6,8] or with different mechanisms of NVD (static or dynamic) [3,8]. Furthermore, minimally-invasive TCRF treatment does not preclude subsequent surgery if the patient and/or provider determines that additional interventions are necessary to reach the desired outcome. For example, Han et al. described patients that underwent additional procedures to address turbinate hypertrophy and/or sinus disease even after having a reduction in NOSE score after TCRF treatment of NVD [8].

It is accepted that NV treatment, whether an isolated procedure or as part of a broader set of procedures, is a critical component of successfully improving NAO; NVD has been shown to be present in ≥80% of symptomatic NAO patients with prior septoplasty and/or turbinate reduction [22,23].

Previous meta-analyses on functional rhinoplasty for the treatment of NAO reported a NOSE score effect size of −43.4 (95% CI, −51.0 to −35.8) at 6-12 months [24] and −43.1 (95% CI, −59.6 to −26.6) at 12 months [25]; a study focused on lateral nasal wall repair for the treatment of dynamic NVD reported an effect size of −49.0 (95% CI, −62.1 to −35.8) at >6 months [26]. Rhee et al. also showed a treatment effect of approximately −40 in NAO patients undergoing a mix of surgical procedures (including rhinoplasty, septoplasty, and/or turbinate treatments), based on a systematic review [27]. The results of our NV treatment surgery and all functional rhinoplasty surgery analyses are consistent with these previous findings.

Literature on the contribution of turbinate treatment to the overall effect of surgical treatment of NAO includes mixed results. In a non-randomised comparative study, septorhinoplasty with inferior turbinate reduction surgery resulted in a larger 12-month effect than without turbinate treatment despite being higher at baseline: effect sizes were −53 and −37, respectively [28]. However, 2 randomised trials showed no difference in outcomes after rhinoseptoplasty with and without inferior turbinate treatment with effect sizes on the order of −47/−52 for with/without inferior turbinate reduction [29] and −50/−48 for with/without partial inferior turbinectomy [30]. The minimal differences in the results of our analyses for functional rhinoplasty without concomitant turbinate treatment and all functional rhinoplasty procedures suggest that turbinate treatment may not substantially contribute to the overall treatment effect, which is in alignment with the results of the randomised trials. Another explanation could be that the area of NAO could be better evaluated to determine the site of anatomic nasal obstruction.

Minimal clinically important differences (MCID) based on NOSE score have previously been reported for septoplasty (19.4) [31] and functional, cosmetic, or combined rhinoplasty (24.4) [32]. The WMDs determined in our analyses for TCRF treatment and functional rhinoplasty are substantially larger than the published MCID values; therefore, reflecting a meaningful clinical treatment response.

TCRF treatment of the internal NV can be performed in an office setting with local anesthesia. Although a safety analysis was outside the scope of these meta-analyses, reports on adverse events were available in the studies describing TCRF treatment; no serious device/procedure-related adverse events were reported and the most common adverse event was congestion [5-10]. After systematic review, Sharif-Askary et al. reported the rates for complications listed in the American Society of Plastic Surgeons' consent for rhinoplasty as nasal septal perforation (0-2.6%), infection (0-4%), bleeding (0-23.4%), NAO (0-23.7%), hypertrophic scarring (0.55-9.1%), dehiscence (5%), skin discoloration (1.7-21.8%), firmness (2-2.5%), need for revision surgery (0-10.9%), numbness/paresthesia (4-49.1%), and seroma (7.4%) [33]. The nature of TCRF treatment under local anesthesia and in an office setting means many of these complications are not observed or observed at a much lower rate (in published studies), and while the extent of revision surgery after TCRF treatment has not yet been addressed in the literature, Han et al. reported only 17% of patients had persistent severe/extreme NAO at 12 months postprocedure [8].

The limitations of this systematic review and meta-analyses include the focus on NOSE score as an outcome measure and the difference in the number of datapoints when comparing TCRF treatment with all functional rhinoplasty procedures. However, NOSE score is a validated outcome measure across a wide range of cultures and languages and with strong specialty consensus around its use, which enabled the inclusion of a large number of studies, and published data on TCRF treatment continues to increase as more practitioners adopt the approach. Follow-up was limited to 12 months to maximise the amount of evaluable data in each analysis group as studies with >12-month follow-up are substantially fewer. It is possible that individual patients in a dataset had a NOSE score reflecting less than moderate NAO, however, the NOSE score cutoff of 45 maximised the potential that most of the patients in a dataset exhibited at least moderate NAO based on the NOSE score severity classification system [13]. The number of individual patients with less than moderate NAO is likely to be small and unlikely to influence the overall outcomes of the meta-analyses. While the included traditional-procedure studies were mostly of moderate to poor quality, and heterogeneity scores were often very high, the large number of studies included in these meta-analyses are a broad representation of the functional rhinoplasty literature.

Conclusion

Pooled effect sizes from datasets including adults with a preprocedural baseline NOSE score indicative of at least moderate NAO showed TCRF treatment of the internal NV is associated with symptom improvements comparable to outcomes after functional rhinoplasty focused on the NV and separately, functional rhinoplasty without concomitant turbinate treatment. Furthermore, outcomes were comparable for the comparison of TCRF treatment of the NV to all functional rhinoplasty surgery, which included a mix of surgical techniques and procedures, including concomitant septoplasty and turbinate treatment. Considering TCRF treatment of the NV does not preclude subsequent surgical treatment if required, practitioners and patients should consider this minimally-invasive treatment when reviewing treatment options to correct NAO secondary to NVD.

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Authorship contribution

Author contributions are noted in the text. In addition, JH and LEI contributed to study design. All authors contributed to dataset inclusion, data interpretation, and manuscript preparation.

Conflict of interest

Joseph Han is a research consultant for Aerin Medical, Medtronic, Intersect ENT, Genentech, Sanofi Genzyme, Astra Zeneca, and GlaxoSmithKline. Julie Perkins was supported by Aerin Medical for this research. David Lerner has no disclosures. Michael Yim is a consultant for Acclarent/J&J and Chitogel. Lisa Ishii has no disclosures.

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This manuscript contains online supplementary material

SUPPLEMENTARY MATERIAL

The supplemental material is referenced independently from the main manuscript.

Supplemental Methods

1. Databases were searched from 2004 (the nasal obstruction symptom evaluation (NOSE) scale was first described in 2004 [(1)]) through December 05, 2022 using search terms/keywords:
   - Medline (via PubMed): ((rhinoplasty) OR (nasal valve)) AND (nasal obstruction)
   - Embase: ((rhinoplasty) OR (nasal valve)) AND (nasal obstruction)
   - Cochrane Library: rhinoplasty, nasal valve, nasal obstruction, rhinoseptoplasty
2. Search results were exported to file types compatible with EndNote™ (Clarivate).
3. Search results were compiled in EndNote and duplicates removed using the 'Find Duplicates' tool. Duplicates were deleted. Subsequent manual search for duplicates was also performed.
4. The language field of EndNote was used to identify and exclude articles not in English language.
5. The title field of EndNote was used to identify and exclude: case report, invited, comment (commentary), editor (editorial), reply, guideline, systematic review, meta-analysis, review, pediatric, child, trauma, fracture, dog, cadaver, cleft lip, fluid dynamics, tumor.
6. The abstract and title fields (EndNote) of remaining articles were used to categorise articles to facilitate subsequent review. Keywords were used in order: valve, rhinoplasty, rhinoseptoplasty, septoplasty, deviat (deviation/deviated), sept (septal/septum).
7. All fields (EndNote) of remaining articles were used to identify articles with NOSE scale/score data using search terms: symptom evaluation, symptoms evaluation, NOSE score, NOSE scale, (NOSE), NOSE questionnaire, obstruction evaluation, septoplasty effectiveness.
8. A small number of additional articles were identified via manual search, based on the review of applicable articles.
9. Search results were exported to Microsoft Excel for abstract review tracking and data extraction.
10. Articles were assigned an identification number for tracking purposes (Table 6). Abstracts were reviewed for potential inclusion against eligibility criteria (Table 3) and ineligible studies were excluded. If eligibility was unclear from the abstract, the article was maintained until full-text review.
11. The full text of articles was reviewed for eligibility criteria and data extracted into prepared Microsoft Excel data collection sheets. If an article contained data from more than one eligible group, data were extracted separately and assigned an article identification number indicating the same source (e.g., XX and XX.1).
12. Studies were also allocated to the without concomitant turbinate treatment and nasal valve treatment only analyses during full-text review.
13. Eligibility for analyses was independently confirmed by a second researcher. Misalignments were resolved by discussion, as necessary.
14. MINORS score allocations were independently confirmed by a second researcher. Misalignments were resolved by discussion, as necessary.
15. Data extraction accuracy was independently checked by a second researcher. Misalignments were resolved by re-review, as necessary.
16. Data collection sheets were used to generate data summaries and were the source data sheets for statistical analysis.
17. Statistical analysis was performed per the statistical methods section.
18. Statistical analysis outputs were used to generate forest plots and tabulated results in Microsoft Excel.

Supplemental Table 1. PRISMA checklist [a,b].

Section/Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	p1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Abstract per journal format
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	p1
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	p1
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	p2 and Supplemental Table 3
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.	p2 and Supplemental Methods
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	p2 and Supplemental Methods
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.	p2-3 and Supplemental Methods
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.	p3 and Supplemental Methods
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.	Supplemental Table 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.	Supplemental Table 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.	p6 (Egger's test) publication bias and study quality assessed by LoE score and MINORS score – p3 and p6
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.	p6 and Supplemental Table 2/3
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)).	Supplemental Methods
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	p6 and Supplemental Table 3
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Supplemental Methods
	13d	Describe any methods used to synthesise 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.	p6
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g., subgroup analysis, meta-regression).	N/A – multiple groups analyzed
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesised results.	N/A

Section/Topic	Item #	Checklist item	Location where item is reported
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	p6 (Egger's test)
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	p6 and Supplemental Table 10 - I2
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.	p6, p9 and Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Supplemental Table 3 inclusion criteria expansion
Study characteristics	17	Cite each included study and present its characteristics.	Table 1 and Supplemental Table 6/7
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	p6 (Egger's test), p9. Supplemental Table 8/9 for LoE score and MINORS score
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.	Supplemental Table 6/7, Figure 2/3, Supplemental Figure 1/2/3
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	p9, Supplemental Table 7/8/9
	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.	Figure 2/3, Supplemental Figure 1/2/3, Table 2, Supplemental Table 10
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Multiple groups analysed - Figure 2/3, Supplemental Figure 1/2/3, Supplemental Table 10
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesised results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	p6 (Egger's test)
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Table 2 and Supplemental Table 10
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	p9-11
	23b	Discuss any limitations of the evidence included in the review.	p10-11
	23c	Discuss any limitations of the review processes used.	p10-11
	23d	Discuss implications of the results for practice, policy, and future research.	p11
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.	Not registered
	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.	p11
Competing interests	26	Declare any competing interests of review authors.	p11
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.	Data in supplementary material only

[a] 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. [b] Template downloaded from http://www.prisma-statement.org/ in March 2023.

Supplemental Table 2. PICO statement.

Patient/population	Adult patients with nasal airway obstruction (refer to Supplemental Table 3 for more information).
Intervention	Temperature controlled radiofrequency (TCRF) treatment of the nasal valve with the VivAer® device (Aerin Medical).
Comparison	Functional rhinoplasty
Comparison (additional analysis)	Functional rhinoplasty without concomitant turbinate treatment – included studies in which there was no reference to turbinate treatment (refer to Supplemental Table 6 for dataset assignment to this analysis).
Comparison (additional analysis)	Functional rhinoplasty of the nasal valve (refer to Supplemental Table 6 for dataset assignment for this analysis). • Includes, for example, datasets in which patients were treated with spreader graft, lateral crural strut graft, butterfly graft, alar batten graft, or similar surgical procedures. • Barham et al. 2015 [2] "When making the structural components of the external nasal valve more rigid, other components of the lateral nasal wall, such as the internal valve, may be affected. There is no way to isolate the effects of the interventions described, and it is highly likely that the surgical maneuvers affect components of both the internal and external valve." • Datasets treating the internal nasal valve and external nasal valve were included in this analysis. • Datasets in which other procedures (e.g., septoplasty alone) were performed were excluded from this analysis. • Datasets with turbinate treatment were excluded from this analysis.
Outcome	Nasal obstruction symptom score (NOSE) scale score on a scale of 0-100 (refer to Supplemental Table 3 for more information). Difference in NOSE score between preprocedural baseline and follow-up at 3, 6, and 12 months postprocedure (refer to Supplemental Table 3 for more information).

Supplemental Table 3. Eligibility criteria and follow-up timepoint allocation.

Criterion	Additional information (if any)
Inclusion criteria	
TCRF treatment of the nasal valve	With the VivAer procedure (Aerin Medical, Sunnyvale, CA, USA).
Functional rhinoplasty	Studies including groups of patients that underwent functional rhinoplasty (primary or revision) with or without concomitant procedures including septoplasty and turbinate treatment. Refer to Supplemental Table 6 for a summary of the procedures in each study.
Exclusion criteria	
<10 patients (at baseline)	-
NOSE score <45 at baseline	Based on mean or median score at preprocedural (as described in the study) baseline.
No evidence of NOSE Scale validation	Refer to Supplemental Table 4.
Follow-up <3 months	Based on reported mean or median timepoint.
Follow-up >12 months	Based on reported mean or median timepoint
Pediatric populations	Populations in which there were patients <16 years in a largely adult population (based on mean age) are identified in Supplemental Table 7.
Septoplasty only	-
Reduction rhinoplasty	-
Maxillary surgery (maxillary expansion)	-
Maxillomandibular advancement	-
Stents only	-
Bioabsorbable implant	Latera, including studies with groups compared to Latera.
Caudal septal deviation treatment focus	-
Tip focus only	-
Insufficient NOSE score data quality	
NOSE score based on individual question scores	i.e., only an overall NOSE score on a scale of 0-100 was sufficient. NOSE score data reported on a scale of 0-20 was multiplied by 5 for analysis.
No specific follow-up time limit for follow-up NOSE score	e.g., follow-up described as ≥6 months or ≥12 months with no indication of the upper time limit. If a dataset was reported with ≥6 months or ≥12 months data, then data at the ≥6 months timepoint in the dataset were included in the 6-month timepoint of analyses.
No NOSE scores	-

Criterion	Additional information (if any)
No baseline NOSE score	-
No follow-up NOSE score	-
No NOSE score width data	e.g., no standard deviation, confidence interval, interquartile range, quartiles. Range alone was insufficient.
Data published again in longer-term follow-up study	e.g., 3-month data was reported again in a report detailing 12-month follow-up. In this scenario, data from the 12-month report (analysed as a complete dataset) would be extracted for analysis.
Instrument evaluation only	e.g., data and/or data reporting method to support patient reported outcome measure validation only with no other information on the procedures or population.
Alternate data analysis groups	Data were reported based on analyses specific to the objective of the publication that could have introduced bias to the patient population.
Other (reason)	Reasons included: Non-surgical, non-surgical conservative treatment in cohort, study protocol, overlap with data in other included articles, nasal dorsal reconstruction.
***Mean follow-up timepoint allocation**	
If mean/median follow-up reported as ≤4.5 months	Included in the 3-month timepoint.
If mean/median follow-up reported as >4.5 months	Included in the 6-month timepoint.
If mean/median follow-up reported as ≤9 months	Included in the 6-month timepoint.
If mean/median follow-up reported as >9 months	Included in the 12-month timepoint.
If mean/median follow-up reported as ≤18 months	Included in the 12-month timepoint.
If mean/median follow-up reported exactly on a divider	Included in the earlier timepoint for a conservative approach.
If follow-up described as e.g., 6-12 months	Included in the 6-month timepoint for a conservative approach.

Supplemental Table 4. NOSE scale validation (language) evidence.

Language	Evidence of validation
Arabic/Egyptian	Validation and cross-cultural adaptation of the Arabic version of the nasal obstruction symptom evaluation scale [3]
English	Development and validation of the nasal obstruction symptom evaluation (NOSE) scale [1]
Chinese	[Development of the Chinese nasal obstruction symptom evaluation (NOSE) questionnaire] [4]
Dutch	Adaptation and validation of the Dutch version of the nasal obstruction symptom evaluation (NOSE) scale [5]
French	French validation of the NOSE and RhinoQOL questionnaires in the management of nasal obstruction [6]
German	[Adaptation of the "nasal obstruction symptom evaluation" (NOSE) questionnaire in the German language] [7] Adaption and validation of the nasal obstruction symptom evaluation scale in German language (D-NOSE) [8]
Greek	Validation of the nasal obstruction symptom evaluation (NOSE) scale for Greek patients [9]
Italian	Reliability and validity of the Italian nose obstruction symptom evaluation (I-NOSE) scale [10]
Indonesian	Validitas dan reliabilitas kuesioner nasal obstruction symptom evaluation. (NOSE) dalam Bahasa Indonesia [11]
Lithuanian	Cross-cultural adaptation and validation of Lithuanian-NOSE scale [12]
Polish	Clinical Evaluation of a Polish translation and cross-cultural adaptation of the nasal obstruction symptom evaluation (NOSE) Scale [13]
Portuguese	Cross-cultural adaptation and validation of a quality-of-life questionnaire: the nasal obstruction symptom evaluation questionnaire [14]
Serbian	Introducing Nasal Obstruction Symptom Evaluation (NOSE) scale in clinical practice in Serbia: Validation and cross-cultural adaptation [15]
Slovenian	Cross-cultural adaptation and validation of nasal obstruction symptom evaluation questionnaire in Slovenian language [16]
Spanish (Latino)	Validation of the nasal obstruction symptom evaluation scale in Mexican adults [17]
Spanish (Spain)	Adaptation and validation of the Spanish version of the nasal obstruction symptom evaluation (NOSE) Scale [18]
Turkish	Reliability and validity of the Turkish nose obstruction symptom evaluation (NOSE) scale [19]
Pediatric populations not included in review, but for informational purposes	
Pediatric	Validation of the nasal obstruction symptom evaluation scale in pediatric patients [20]

Supplemental Table 5. Level of evidence reference table [a].

Quality rating scheme for studies and other evidence	
1	Properly powered and conducted randomised clinical trial; systematic review with meta-analysis
2	Well-designed controlled trial without randomisation; prospective comparative cohort trial *Assigned to studies comparing different graft types, for example.* [b]
3	Case-control studies; retrospective cohort study *Assigned to retrospective comparative cohort studies.* [b]
4	Case series with or without intervention; cross-sectional study *Assigned to single-arm prospective studies (if a pooled single dataset was extracted from a study that also included comparative datasets, it was considered a case series [a single-arm study]). Prospective or retrospective. A collection of case reports (sometimes termed a case series in the literature) was assigned a score of 5 (case reports).* [b]
5	Opinion of respected authorities; case reports

[a] Reproduced from https://jamanetwork.com/journals/jamaotolaryngology/pages/instructions-for-authors, accessed March 2023.

[b] Clarifications of assignments.

Supplemental Table 6. Study/dataset list – demographics, baseline characteristics, and procedurea.

ID [b]	First author	Year	Demo N [c]	Male		Female		Age (yr)		BL N [d]	BL NOSE score [e]		Follow-up [f]			Procedure(s) and/or treatment summary [g]	Analysis [h]	
				n	%	n	%	Mn	SD		Value	Width	3M	6M	12M		Turb	NV
37	Brehmer	2019 [21]	31	14	45	17	55	43	11	31	65	21.3	Y	-	-	TCRF treatment (VivAer).	No	Yes
38	Ephrat	2021 [22]	39	19	49	20	51	52	13	39	80.8	74.1-87.5	-	Y	Y	TCRF treatment (VivAer).	No	Yes
42	Wu	2021 [23]	18	12	67	6	33	46	17	18	78.9	11.6	Y	-	-	TCRF treatment (VivAer).	No	Yes
230	Yao	2021 [24]	122	58	48	64	53	50	16	122	80.3	12.6	Y	-	-	TCRF treatment (VivAer).	No	Yes
39	Han	2022 [25]	108	42	39	66	61	49	12	108	76.3	73.6-79.1	Y	Y	Y	TCRF treatment (VivAer).	No	Yes
43	Abdelwa-hab	2021 [26]	59	-	-	-	-	-	-	59	58.9	30.6	-	-	Y	LCSG in patients with a lateral wall insufficiency (nasal side wall collapse). Other groups in the publication were excluded based on baseline NOSE score <45.	No	Yes
25	Aladag	2019 [27]	32	21	66	11	34	35	12	32	72.7	9.6	-	Y	-	INV expanding graft, a modification of the splay graft technique: placing the resected septal cartilage deep to the upper lateral cartilages to prevent midvault collapse and INV incompetency.	No	Yes
163	Alan i	2022 [28]	19	9	47	10	53	23	4	19	65.7	23.4	Y	-	Y	Structural rhinoplasty. SG for midvault reconstruction, resection of dorsal septum, upper lateral cartilage, bony hump as needed, medial oblique and lateral osteoto-mies, columellar strut graft routinely used, tip plasty, septoplasty as needed. ITR with radiofrequency and in/outfracture.	Yes	No
163.1	Alan ii	2022 [28]	15	8	53	7	47	24	7	15	69.3	19.3	Y	-	Y	Preservation rhinoplasty. Push-down technique after releasing the nasal pyramid, tip surgery (as above), septoplasty as needed. ITR with radiofrequency and in/outfracture.	Yes	No
11	Albergo	2020 [29]	33	28	85	5	15	32	12	33	73.6	17.4	-	-	Y	SG treatment of patients with severe septal deviation and INV compromise.	No	No
119	Andrews	2015 [30]	121	77	63.6	44	36.4	34	12	121	70.5	25.0	Y	-	-	Functional and reconstructive septorhinoplasty.	No	No
146	Andrews	2021 [31]	530	397	75	128	24	34	-	216	69.8	16.9	Y	-	-	Rhinoplasty group, whole population (publication includes smoking status subgroup analysis military care facility). Inferior turbinoplasty assumed.	Yes	No
26	Barham	2015 [2]	41	17	41	24	59	-	-	41	60.0	21.5	-	-	Y	Primary intervention – lateral crura augmented by cephalic turn-in maneuver. Re-vision intervention – lateral crura augmented or replaced with underlay strut grafts using costal cartilage. Correction of septal deformities as needed. Whole group data. Turbinoplasty.	Yes	No
120	Başer	2016 [32]	45	29	64	16	36	32	31	45	76.9	22.6	-	-	Y	Open approach septorhinoplasty. Medial and lateral osteotomies, caudal septum corrections as necessary, tip modifications as necessary, alar cartilages excised or augmented as required.	No	No
13	Bessler	2015 [33]	43	28	65	15	35	30	-	43	75.1	9.7	-	-	-	Anterior spreader flap technique – folding the caudal part of the upper lateral carti-lage inwards, aligning the dorsal border of the nasal septum. Included septoplasty as needed. Turbinoplasty.	Yes	No
164	Burks i	2022 [34]	113	56	50	57	50	37	15	113	65.1	21.2	-	Y	-	SG with dorsal hump reduction. No additional grafts or techniques.	No	Yes
164.1	Burks ii	2022 [34]	113	80	71	33	29	29	12	113	62.4	23.0	-	Y	-	SG without dorsal hump reduction. No additional grafts or techniques.	No	Yes
27	Calloway	2019 [35]	90	28	31	62	69	38	-	90	70.4	24.9	-	Y	-	Articulated alar rim graft in combination with mixture of SG, rim grafts, CSEG, lateral crural tensioning. Inferior turbinate submucosal resection and outfracture.	Yes	No
65	Chambers	2015 [36]	40	23	57	17	43	39	-	40	75.7	20.1	Y	-	-	NV correction by graft placement after failed septoplasty. Graft determined by posi-tion of NV dysfunction: SG, columellar strut graft, LCSG, alar rim graft, flaring suture, correction of medial crural flare, caudal extension graft.	No	Yes
166	Datema	2017 [37]	171	93	54	78	46	35	-	97	65.0	24.6	Y	-	-	Functional rhinoplasty.	No	No
150	de Moura i	2018 [38]	25	14	56	11	44	36	13	23	69.2	25.6	Y	-	-	With endoscopic partial inferior turbinectomy. Functional rhinoplasty: SG, lateral strut graft, tongue in groove, shield graft, alar rim graft, septal extension. Endoscopic partial inferior turbinectomy.	Yes	No
150.1	de Moura ii	2018 [38]	24	10	44	14	56	36	16	21	80.2	13.6	Y	-	-	Without endoscopic partial inferior turbinectomy. Functional rhinoplasty: SG, lateral strut graft, turn-in flap, tongue in groove.	No	No

ID [b]	First author	Year	Demo N [c]	Male		Female		Age (yr)		BL N [d]	BL NOSE score [e]		Follow-up [f]			Procedure(s) and/or treatment summary [g]	Analysis [h]	
				n	%	n	%	Mn	SD		Value	Width	3M	6M	12M		Turb	NV
68	Dolan	2010 [39]	29	22	76	7	24	49	-	24	66.7	17.1	Y	-	-	NV repair by fibrocartilaginous resection and imbrication at the caudal upper lateral cartilage.	No	Yes
69	Eren	2014 [40]	15	8	53	7	47	32	6	15	65.0	13.0	-	-	Y	Autospreading spring flap technique for reconstruction of the middle vault – ap-positions only the medial part of the upper lateral cartilages and suturing it to the dorsal septal cartilage. Middle concha bullosa crushing as needed. Septal deviation corrected if needed . Outfracture and inferior (turbinate) radiofrequency.	Yes	No
14	Erickson	2016 [41]	17	16	94	1	6	35	12	17	70.0	16.5	Y	-	-	Endonasal SG placed into a submucosal pocket inferior to the superior edge of the upper lateral cartilage. Septoplasty. Inferior turbinoplasty.	Yes	No
46	Fuller	2017 [42]	135	75	56	59	44	37	15	135	66.0	21.4	-	Y	-	Functional rhinoseptoplasty: SG, columellar strut graft, LCSG, alar rim graft, extended SG, alar batten graft, dorsal onlay, lateral crural replacement.	No	No
125	Fuller	2017 [43]	88	45	51	43	49	34	16	62	65.2	22.1	-	Y	Y	Polydioxanone plates for L-strut support in addition to SG, columellar strut graft, alar rim graft, LCSG.	No	No
15	Fuller	2019 [44]	154	72	47	82	53	37	15	154	62.7	20.7	-	Y	-	SG and SG plus alar rim graft, LCSG, columellar strut graft.	No	No
124	Fuller	2019 [45]	281	122	43	159	57	36	16	281	61.8	59.2-64.4	-	Y	-	SG, columellar strut graft, LCSG, alar rim graft, lateral crural replacement.	No	No
126	Gerecci	2019 [46]	49	17	35	32	65	44	14	49	71.4	17.0	Y	-	-	SG, butterfly graft, lower lateral cartilage graft, alar rim graft, nasal tip support graft, tip graft, alar base reduction, septal transplant, osteotomy, septal transplant. ITR.	Yes	No
171	Gökçe Kütük	2019 [47]	90	32	36	58	64	27	7	90	75	65-85	Y	Y	-	Open and closed rhinoplasty. Combined groups.	No	No
172	Gökçe Kütük	2022 [48]	51	18	35	33	65	28	6	51	70.1	18.0	Y	-	-	Rhinoplasty.	No	No
47	Goudakos	2017 [49]	46	17	37	29	63	35	-	46	61.0	15.0	-	Y	Y	Revision rhinoplasty. SG, cap graft, alar graft, Columellar strut graft, caudal extension graft, dorsal augmentation graft, LCSG, shield graft, awengen graft. Septoplasty.	No	No
173	Günel i	2015 [50]	79	49	62	30	38	24	5	57	60	30-75	Y	Y	-	External septorhinoplasty – primary.	No	No
173.1	Günel ii	2015 [50]	-	-	-	-	-	-	-	22	52.5	37.5-70	Y	Y	-	External septorhinoplasty – secondary.	No	No
127	Hismi	2020 [51]	125	60	48	65	52	38	16	122	60.4	21.8	-	Y	Y	SG, extended SG, LCSG, Columellar strut graft, alar rim graft, spreader (no release), lateral crural replacement. Whole group.	No	No
111	Hismi i	2022 [52]	104	333	47	371	53	40	14	75	70	50-85	Y	Y	Y	SG+alar rim graft.	No	Yes
111.1	Hismi ii	2022 [52]	141	-	-	-	-	46	15	109	70	55-83	Y	Y	Y	SG+LCSG.	No	Yes
111.2	Hismi iii	2022 [52]	218	-	-	-	-	33	13	162	65	45-75	Y	Y	Y	SG alone.	No	Yes
129	Inan i	2022 [53]	57	40	34	79	66	27	9	57	76.4	11.9	Y	-	-	Septorhinoplasty (open technique) with concha bullosa resection of bulbous or extensive type middle turbinate. Radiofrequency ablation of inferior turbinates.	Yes	No
129.1	Inan ii	2022 [53]	62	40	34	79	66	27	9	62	71.3	12.9	Y	-	-	Septorhinoplasty (open technique) - normal or lamellar-type middle turbinate. Radiofrequency ablation of inferior turbinates.	Yes	No
174	İnan	2022 [54]	97	24	25	73	75	27	8	97	56.5	20.8	Y	-	-	Septorhinoplasty. Radiofrequency thermal ablation of inferior turbinates	Yes	No
29	Islam	2008 [55]	11	5	45	6	55	35	-	11	73.6	14.8	-	-	Y	Modified splay graft technique with endonasal approach.	No	Yes
130	Justicz i	2019 [56]	141	-	-	-	-	44	15	18	71.7	20.1	-	Y	Y	Septorhinoplasty (open approach) using irradiated homologous costal cartilage. Other grafts: SG/extended spreader, LCSG, Columellar strut graft, alar rim graft, polydioxanone plate L-strut, dorsal onlay.	No	No
130.1	Justicz ii	2019 [56]	141	-	-	-	-	44	15	80	68.5	24.1	-	Y	Y	Septorhinoplasty (open approach) using autologous costal cartilage. Other grafts: SG/extended spreader, LCSG, Columellar strut graft, alar rim graft, polydioxanone plate L-strut, dorsal onlay.	No	No
178	Kandathil	2021 [57]	99	58	59	41	41	40	15	99	71.0	19.0	Y	Y	Y	Functional rhinoplasty. Potential overlap with dataset in study ID 180.	No	No

ID [b]	First author	Year	Demo N [c]	Male		Female		Age (yr)		BL N [d]	BL NOSE score [e]		Follow-up [f]			Procedure(s) and/or treatment summary [g]	Analysis [h]	
				n	%	n	%	Mn	SD		Value	Width	3M	6M	12M		Turb	NV
180	Kandathil	2021 [58]	90	54	60	36	40	39	15	90	69.2	18.7	Y	Y	Y	Rhinoplasty. Potential overlap with dataset in study ID 178.	No	No
229	Kaura	2019 [59]	70	44	63	26	37	34	-	69	74.8	22.3	-	Y	-	Functional external septorhinoplasty included INV augmentation and columellar strut graft augmentation, septal correction surgery.	No	No
153	Lavinsky-Wolff i	2013 [60]	25	8	32	17	68	32	12	25	70.8	23.2	Y	-	-	Rhinoseptoplasty with inferior turbinate reduction. Septoplasty, nasal tip refinement, dorsal profile alignment, lateral and medial osteotomy. No SG, batten grafts, or flaring sutures. ITR through submucosal diathermy.	Yes	No
153.1	Lavinsky-Wolff ii	2013 [60])	25	13	52	12	48	32	15	24	77.2	18.9	Y	-	-	Rhinoseptoplasty without inferior turbinate reduction. Septoplasty, nasal tip refinement, dorsal profile alignment, lateral and medial osteotomy. No SG, batten grafts, or flaring sutures.	No	No
50	Lindsay i	2012 [61]	60	43	72	17	28	40	-	30	72.2	17.3	-	Y	-	INV and ENV treatment with grafts SG, LCSG, and sutures. Septoplasty.	No	No
50.1	Lindsay ii	2012 [61]	-	-	-	-	-	-	-	14	61.8	23.3	-	Y	-	INV treatment with SG and flaring suture. Septoplasty.	No	No
50.2	Lindsay iii	2012 [61]	-	-	-	-	-	-	-	16	59.7	20.7	-	Y	-	ENV treatment with LCSG. Septoplasty.	No	No
115	Loyo	2016 [62]	34	11	32	23	68	46	19	19	67.9	19.4	-	Y	Y	Modified butterfly graft. ITR.	Yes	No
185	Martin	2022 [63]	54	32	59	22	41	30	-	52	63.8	20.9	-	Y	-	Septorhinoplasty group only (septoplasty group also in study). Patients were randomised for additional turbinoplasty.	Yes	No
52	Most	2006 [64]	41	27	66	14	34	42	-	41	58.4	13.4	-	Y	-	Whole group. SG for INV treatment. Bone-anchored sutures to orbital rim for ENV treatment. Septoplasty. Turbinectomy.	Yes	No
155	Nural	2019 [65]	63	22	35	41	35	30	9	63	67.2	36.2	-	Y	-	Crooked nose treatment. Open technique. SG, dorsal hump removal, osteotomy, cap and shield grafts as appropriate. Group 1 data.	No	No
84	Palesy	2015 [66]	19	6	32	13	68	33	12	19	60.5	21.6	-	Y	-	Primary intervention – lateral crural cephalic turn-in alone. Revision intervention – lateral crural underlay strut grafts using costal cartilage.	No	Yes
53	Pecorari	2017 [67]	15	7	47	8	53	38	11	15	69.7	42.0	-	Y	-	Rhinoplasty: lateral crura of alar cartilage reduced in vertical dimension cephalic resection. Septoplasty, medial and lateral osteotomy, remodeling of alar cartilage.	No	No
137	Radulesco	2018 [68]	35	13	37	22	63	32	-	35	72.5	21.7	-	-	Y	SG, autospreader graft, alar batten graft, sutures involving the nasal valve, cartilaginous resections. Septoplasty.	No	No
86	Rhee	2005 [69]	20	3	15	17	85	34	-	20	68.9	20.9	Y	Y	-	SG with/without flaring sutures to address midvault. Alar batten graft. Septoplasty or septal cartilage harvesting, Turbinate reduction.	Yes	No
196	Rudes	2018 [70]	122	47	39	75	62	32	13	122	47.5	26.2	-	Y	-	SG, autospreader technique, LCSG, upper lateral flaring suture, alar batten graft. Septoplasty. Turbinate reduction with complete preservation of mucosa and submucosa.	Yes	No
20	Sahin	2016 [71]	22	13	59	9	41	21	2	22	64.3	59.5-69.2	Y	-	-	Modified triangular SG. Hump resection, lateral/medial osteotomies, Columellar strut graft. Septoplasty. ITR with submucosal diathermy.	No	No
197	Şahin i	2022 [72]	40	20	50	20	50	29	9	40	72.8	23.6	-	-	Y	SG for middle vault reconstruction.	Yes	No
197.1	Şahin ii	2022 [72]	26	15	58	11	42	33	9	26	85.0	7.0	-	-	Y	L-strut graft for middle vault reconstruction.	Yes	No
54	Shafik	2020 [73]	20	14	70	6	30	22	3	20	67.5	7.9	Y	-	-	Rhinoplasty.	No	No
21	Sowder i	2017 [74]	-	-	-	-	-	-	-	20	81.9	15.8	-	-	Y	Spreader flap without dorsal hump removal or osteotomy. Septoplasty. ITR.	Yes	No
21.1	Sowder ii	2017 [74]	-	-	-	-	-	-	-	24	75.4	19.3	-	-	Y	SG without dorsal hump removal or osteotomy. Septoplasty. ITR.	Yes	No
34	Taha i	2021 [75]	10	6	60	4	40	40	6	10	80.1	5.8	-	-	Y	ENV treated with costal cartilage LCSG – primary. Medial flap turbinoplasty.	Yes	No
34.1	Taha ii	2021 [75]	16	10	62	6	38	41	13	16	70.0	19.1	-	-	Y	ENV treated with costal cartilage LCSG – revision. Medial flap turbinoplasty.	Yes	No
96	Tan	2012 [76]	15	7	47	8	53	46	-	15	86.5	8.0	-	-	Y	Lateral crural j-flap repair of ENV collapse.	No	Yes
35	Tastan	2011 [77]	19	11	58	8	42	-	-	19	75.8	12.4	-	-	Y	H-graft technique for INV reconstruction.	No	Yes

ID [b]	First author	Year	Demo N [c]	Male		Female		Age (yr)		BL N [d]	BL NOSE score [e]		Follow-up [f]			Procedure(s) and/or treatment summary [g]	Analysis [h]	
				n	%	n	%	Mn	SD		Value	Width	3M	6M	12M		Turb	NV
55	Tjahjono	2019 [78]	144	59	41	85	59	38	13	144	48.2	19.2	-	Y	-	Open septorhinoplasty. Turbinate reduction.	Yes	No
161	Tugrul	2019 [79]	28	-	-	-	-	28	4	28	69.5	17.4	-	-	Y	Open septorhinoplasty.	No	No
208	Vaezeaf-shar	2018 [80]	44	8	18	36	82	46	16	44	69.4	22.0	Y	-	Y	Group 1. SG, LCSG, alar rim graft, alar batten graft. Septoplasty, anterior septal reconstruction, osteotomy, autospreader. Turbinate reduction.	Yes	No
209	van Zijl	2022 [81]	363	184	51	179	49	36	-	357	66.6	23.5	-	-	Y	Rhinoplasty.	No	No
23	Weitzman	2021 [82]	568	293	52	272	48	35	15	276	49.7	25.2	-	Y	-	SG. Columellar strut graft, alar rim graft, alar batten graft, LCSG, dorsal onlay, lateral crural replacement, small number of other procedures (unidentified).	No	Yes
23.1	Weitzman	2021 [82]	126	68	54	58	46	43	16	41	50.0	28.7	-	Y	-	Extended SG. Columellar strut graft, alar rim graft, alar batten graft, LCSG, dorsal onlay, lateral crural replacement, small number of other procedures (unidentified).	No	Yes
212	Weitz-man i	2022 [83]	559	287	52	269	48	35	15	315	63.4	22.3	-	Y	-	SG with upper lateral cartilage release group. Columellar strut graft/septal extension graft, alar rim graft, alar batten graft, LCSG, dorsal onlay.	No	No
212.1	Weitz-man ii	2022 [83]	30	18	60	12	40	35	15	10	65.0	4.6	-	Y	-	SG without release group. Columellar strut graft/septal extension graft, alar rim graft, LCSG.	No	No
145	Yamasaki i	2019 [84]	391	179	46	211	54	36	16	347	61.5	59.9-62.4	Y	Y	Y	Septorhinoplasty without inferior turbinate reduction. Columellar strut graft, alar rim graft, LCSG, lateral crural replacement. Septoplasty.	No	No
145.1	Yamasaki ii	2019 [84]	176	88	50	88	50	36	14	166	66.6	65.1-68.1	Y	Y	Y	Septorhinoplasty with inferior turbinate reduction. Columellar strut graft, alar rim graft, LCSG, lateral crural replacement. Septoplasty. ITR techniques included medial flap turbinoplasty and submucous resection using microdebrider, electrocautery, or coblation.	Yes	No
216	Yamasaki	2020 [85]	625	291	47	334	53	36	16	495	65.0	63.0-67.1	Y	Y	Y	SG, LCSG, alar rim graft, Columellar strut graft. Septoplasty, closed nasal reduction. Turbinoplasty.	Yes	No
56	Yeung	2016 [86]	79	30	48	41	52	36	14	79	67.1	19.7	Y	-	-	SG, alar batten graft. Septoplasty	Yes	No
24	Yoo	2011 [87]	17	-	-	-	-	-	-	17	57.4	21.0	-	Y	-	Autospreader flap. Septoplasty, bone-anchored suture technique. ITR	Yes	No

Abbreviations: BL, Pretreatment baseline; CSEG, caudal septal extension graft; ENV, external nasal valve; INV, internal nasal valve; ITR, inferior turbinate reduction; LCSG, lateral crural strut graft; NV, nasal valve; SG, spreader graft; TCRF, temperature-controlled radiofrequency.

[a] Studies are listed in alphabetical order of the first author, then the year of publication. Studies that included more than 1 dataset are assigned the same study identification number plus .1, .2, etc and listed together. Datasets from the same study are indicated by blue or green shading.

[b] Internal identification number for study/dataset for tracking purposes.

[c] Number of patients for demographics data. In some cases with multiple datasets in the same study, demographics data are reported on the overall population rather than on a dataset level – in these cases, demographics data are listed on just 1 line item.

[d] Number of patients for baseline NOSE score. In some cases, this is different from the number of patients for demographics data.

[e] Baseline NOSE score as reported in each study/dataset. Value refers to the average, as reported. Width refers to the standard deviation, interquartile range, quartiles, confidence interval, or standard error as reported. The mean and standard deviation are listed where available – values in black. Other values are: median/interquartile range (not quartiles) – values in orange, mean/95% confidence interval – values in green, median/25 and 75 quartiles – values in blue, and mean/standard error – values in red.

[f] Y indicates the dataset included follow-up data at 3 months, 6 months, and/or 12 months.

[g] A brief summary of the procedures performed on patients in each dataset.

[h] Indicates datasets included in the additional analyses: Yes in the Turb column indicates turbinate treatment was specifically mentioned in the study (for the dataset). No in the Turb column indicates turbinate treatment was specifically not performed on the patients in the dataset or there was no mention of turbinate treatment in the study (for the dataset) – these datasets were included in the without concomitant turbinate treatment analysis. Yes in the NV column indicates the dataset is included in the nasal valve treatment analysis.

Supplemental Table 7. Study/dataset list – additional study specifics [a].

ID [b]	First author	Year	Location	Prospective Retrospective	Single center Multi-center	Study type [c]	MINORS score (nc) [d]	MINORS score (c) [e]	LoE Score [f]	Age range comment [g]
37	Brehmer	2019 [(21)]	Germany	Prospective	Single	Non-comparative	11	-	4	-
38	Ephrat	2021 [(22)]	USA	Prospective	Multi	Non-comparative	12	-	4	-
42	Wu	2021 [(23)]	USA	Prospective	Single	Non-comparative	11	-	4	-
230	Yao	2021 [(24)]	USA	Prospective	Multi	Non-comparative	11	-	4	-
39	Han	2022 [(25)]	USA	Prospective	Multi	Single cohort (index and crossover) after primary endpoint of RCT	13	-	4	-
43	Abdelwahab	2021 [(26)]	USA	Retrospective	Single	Non-comparative*	9	-	4	-
25	Aladag	2019 [(27)]	Turkey	Retrospective	Single	Non-comparative	9	-	4	-
163	Alan i	2022 [(28)]	Turkey	Prospective	Single	Comparative	-	13	2	-
163.1	Alan ii	2022 [(28)]	-	-	-	-	-	-	-	-
11	Albergo	2020 [(29)]	Argentina	Retrospective	Single	Non-comparative	9	-	4	Individual patient data were reported and therefore, only data from patients ≥16 years were included in the analysis (2 patients in the study dataset were <16 years).
119	Andrews	2015 [(30)]	England	Prospective	Single	Non-comparative*	11	-	4	-
146	Andrews	2021 [(31)]	USA	Retrospective	Single	Non-comparative	7	-	4	-
26	Barham	2015 [(2)]	Australia	Prospective	Single	Non-comparative*	10	-	4	-
120	Başer	2016 [(32)]	Turkey	Retrospective baseline, prospective follow-up	Single	Non-comparative	9	-	4	-
13	Bessler	2015 [(33)]	Switzerland	Retrospective	Single	Non-comparative	7	-	4	-
164	Burks i	2022 [(34)]	USA	Prospective	Single	Comparative	-	15	2	-
164.1	Burks ii	2022 [(34)]	-	-	-	-	-	-	-	-
27	Calloway	2019 [(35)]	USA	Retrospective	Single	Non-comparative	8	-	4	-
65	Chambers	2015 [(36)]	USA	Prospective	Single	Non-comparative	10	-	4	Mean age 39.3 years (no standard deviation reported) in a population of 40 patients; stated age range 12 to 69 years.
166	Datema	2017 [(37)]	Netherlands	Prospective	Single	Non-comparative	10	-	4	Mean age 35 years in a population of 171 patients, stated age range 15 to 74 years.
150	de Moura i	2018 [(38)]	Brazil	Prospective	Single	Randomised	-	22	1	-
150.1	de Moura ii	2018 [(38)]	-	-	-	-	-	-	-	-
68	Dolan	2010 [(39)]	USA	Prospective	Single	Non-comparative	10	-	4	-
69	Eren	2014 [(40)]	Turkey	Prospective	Single	Non-comparative	11	-	4	-

ID [b]	First author	Year	Location	Prospective Retrospective	Single center Multi-center	Study type [c]	MI-NORS score (nc) [d]	MI-NORS score (c) [e]	LoE Score [f]	Age range comment [g]
14	Erickson	2016 (41)	Canada	Prospective	Single	Non-comparative	10	-	4	-
46	Fuller	2017 (42)	USA	Prospective	Single	Non-comparative	9	-	4	-
125	Fuller	2017 (43)	USA	Retrospective	Single	Non-comparative	8	-	4	Mean age (standard deviation) 34.3 (15.7) years in a population of 88 patients; stated age range 7.5 to 71.5 years.
15	Fuller	2019 (44)	USA	Prospective	Single	Non-comparative	10	-	4	-
124	Fuller	2019 (45)	USA	Prospective	Single	Non-comparative	9	-	4	-
126	Gerecci	2019 (46)	USA	Prospective	Single	Non-comparative	11	-	4	-
171	Gökçe Kütük	2019 (47)	Turkey	Prospective	Single	Non-comparative*	11	-	4	-
172	Gökçe Kütük	2022 (48)	Turkey	Prospective	Single	Non-comparative	10	-	4	-
47	Goudakos	2017 (49)	Greece	Retrospective	Single	Non-comparative	9	-	4	-
173	Günel i	2015 (50)	Turkey	Prospective	Single	Comparative	-	14	2	-
173.1	Günel ii	2015 (50)	-	-	-	-	-	-	-	-
127	Hismi	2020 (51)	USA	Prospective	Single	Non-comparative*	-	13	4	-
111	Hismi i	2022 (52)	USA	Prospective	Single	Comparative	-	-	2	-
111.1	Hismi ii	2022 (52)	-	-	-	-	-	-	-	-
111.2	Hismi iii	2022 (52)	-	-	-	-	10	-	-	-
129	Inan i	2022 (53)	Turkey	Retrospective	Single	Comparative	-	11	3	-
129.1	Inan ii	2022 (53)	-	-	-	-	-	-	-	-
174	İnan	2022 (54)	Turkey	Prospective	Single	Non-comparative	11	-	4	-
29	Islam	2008 (55)	Turkey	Prospective	Single	Non-comparative	11	-	4	-
130	Justicz i	2019 (56)	USA	Prospective	Single	Comparative	-	12	3	Mean age (standard deviation) 43.8 (14.7) years in 105 patients; of which 2 patients were ≤16 years (11, 14 years).
130.1	Justicz ii	2019 (56)	-	-	-	-	-	-	-	All patients ≥19 years in this dataset.
178	Kandathil	2021 (57)	USA	Prospective	Single	Non-comparative	9	-	4	-
180	Kandathil	2021 (58)	USA	Retrospective	Single	Non-comparative	7	-	4	-
229	Kaura	2019 (59)	England	Prospective	Single	Non-comparative	11	-	4	-
153	Lavinsky-Wolff i	2013 (60)	Brazil	Prospective	Single	Randomised	-	23	1	-
153.1	Lavinsky-Wolff ii	2013 (60)	-	-	-	-	-	-	-	-
50	Lindsay i	2012 (61)	USA	Prospective	Single	Comparative	-	12	2	-
50.1	Lindsay ii	2012 (61)	-	-	-	-	-	-	-	-
50.2	Lindsay iii	2012 (61)	-	-	-	-	-	-	-	-
115	Loyo	2016 (62)	USA	Retrospective	Single	Non-comparative	7	-	4	-
185	Martin	2022 (63)	Germany	Prospective	Single	Non-comparative*	9	-	4	-
52	Most	2006 (64)	USA	Prospective	Single	Non-comparative*	11	-	4	-
155	Nural	2019 (65)	Turkey	Retrospective	Single	Non-comparative	7	-	4	-

ID [b]	First author	Year	Location	Prospective Retrospective	Single center Multi-center	Study type [c]	MINORS score (nc) [d]	MINORS score (c) [e]	LoE Score [f]	Age range comment [g]
84	Palesy	2015 (66)	Australia	Prospective	Single	Non-comparative	10	-	4	-
53	Pecorari	2017 (67)	Italy	Prospective	Single	Non-comparative*	11	-	4	-
137	Radulesco	2018 (68)	France	Prospective	Single	Non-comparative	10	-	4	-
86	Rhee	2005 (69)	USA	Prospective	Single	Non-comparative	11	-	4	-
196	Rudes	2018 (70)	Germany	Prospective	Single	Non-comparative	10	-	4	-
20	Sahin	2016 (71)	Turkey	Prospective	Single	Non-comparative	9	-	4	-
197	Şahin i	2022 (72)	Turkey	Prospective	Single	Comparative	-	14	2	-
197.1	Şahin ii	2022 (72)	-	-	-	-	-	-	-	-
54	Shafik	2020 (73)	Egypt	Prospective	Single	Non-comparative	12	-	4	-
21	Sowder i	2017 (74)	USA	Retrospective	Single	Comparative	-	10	3	-
21.1	Sowder ii	2017 (74)	-	-	-	-	-	-	-	-
34	Taha i	2021 (75)	USA	Prospective	Single	Comparative	-	13	2	-
34.1	Taha ii	2021 (75)	-	-	-	-	-	-	-	-
96	Tan	2012 (76)	Canada	Prospective	Single	Non-comparative	11	-	4	-
35	Tastan	2011 (77)	Turkey	Prospective	Single	Non-comparative	11	-	4	-
55	Tjahjono	2019 (78)	Australia	Prospective	Multi	Non-comparative	11	-	4	-
161	Tugrul	2019 (79)	Turkey	Retrospective	Single	Non-comparative	9	-	4	-
208	Vaezeafshar	2018 (80)	USA	Retrospective	Single	Non-comparative*	8	-	4	-
209	van Zijl	2022 (81)	Netherlands	Prospective	Single	Non-comparative	10	-	4	-
23	Weitzman i	2021 (82)	USA	Prospective	Single	Comparative	-	12	2	-
23.1	Weitzman ii	2021 (82)	-	-	-	-	-	-	-	-
212	Weitzman i	2022 (83)	USA	Prospective	Single	Comparative	-	12	2	-
212.1	Weitzman ii	2022 (83)	-	-	-	-	-	-	-	-
145	Yamasaki i	2019 (84)	USA	Prospective	Single	Comparative	-	15	2	-
145.1	Yamasaki ii	2019 (84)	-	-	-	-	-	-	-	-
216	Yamasaki	2020 (85)	USA	Prospective	Single	Non-comparative	10	-	4	-
56	Yeung	2016 (86)	USA	Prospective	Multi	Non-comparative	10	-	4	-
24	Yoo	2011 (87)	USA	Prospective	Single	Non-comparative	10	-	4	-

[a] Studies are listed in alphabetical order of the first author, then the year of publication. Studies that included more than 1 dataset are assigned the same study identification number plus .1, .2, etc and listed together. Datasets from the same study are indicated by blue or green shading.

[b] Internal identification number for study/dataset for tracking purposes.

[c] Non-comparative* indicates a single dataset extracted from a study including additional comparative groups that were ineligible for inclusion/a single dataset was extracted; these studies were assessed as non-comparative studies for MINORS score.

[d] MINORS: Methodological index for non-randomised studies instrument score for non-comparative studies. Maximum possible score of 16 (88).

[e] MINORS: Methodological index for non-randomised studies instrument score for comparative studies. Maximum possible score of 24. A single entry for each comparative study (88).

[f] Level of evidence (LoE) score. Refer to Supplemental Table 5 for score assignments and source.

[g] Populations in which it was reported that there were patients aged <16 years in a largely adult population (based on mean age) are identified.

Supplemental Table 8. Study/dataset characteristics summary.

Characteristic, N = 68 studies [a]		
Study, No. (%)		
Prospective	52	(76.5)
Retrospective	16	(23.5)
Contributing centers, No. (%)		
Single center	63	(92.6)
Multicenter	5	(7.4)
Location, No. (%)		
USA	33	(48.5)
Turkey	15	(22.1)
Germany	3	(4.4)
Australia	3	(4.4)
Netherlands	2	(2.9)
Brazil	2	(2.9)
Canada	2	(2.9)
England	2	(2.9)
Argentina	1	(1.5)
Egypt	1	(1.5)
France	1	(1.5)
Greece	1	(1.5)
Italy	1	(1.5)
Switzerland	1	(1.5)
Characteristic, N = 85 datasets [a]		
Dataset size, based on baseline NOSE score N, No. (%) [b]		
Small (≤50 patients)	47	(55.3)
Medium (51-100 patients)	18	(21.2)
Large (>100 patients)	20	(23.5)
No. (%) of datasets with follow-up data at [c]		
3 months	37	(43.5)
6 months	43	(50.6)
12 months	38	(44.7)
3 months only	20	(23.5)
6 months only	23	(27.1)
12 months only	18	(21.2)
3 and 6 months	4	(4.7)
3 and 12 months	4	(4.7)
6 and 12 months	7	(8.2)
3, 6, and 12 months	9	(10.6)
Total patients based on baseline NOSE score N, No. (range) [b]	6519	-
Patients per dataset based on baseline NOSE score N, Median (IQR) [b]	43	(21 to 99)
Patients per dataset based on baseline NOSE score N, (Range) [b]	-	(10 to 495)
Demographics overall summary		
Sex, No. (%) [d]		
Male	4015	(50.9)
Female	3880	(49.1)
Mean age, years, Range [e]	21.4 to 51.7	-

[a] Number of studies; some studies contain one or more groups with data reported separately, in which case each dataset was extracted separately.

[b] The number of patients with NOSE score data – this is sometimes different from the number of patients in demographics tables.

[c] Refer to Supplemental Table 3 for follow-up timepoint allocation.

[d] Based on N = 72 datapoints. In some cases, demographics data are not reported, only reported overall, or reported on a larger N than those with baseline NOSE score. Therefore, the demographics total N is larger than the N with baseline NOSE scores.

[e] The range of mean age based on N = 75 datapoints. In some cases, demographics data are not reported or only reported overall.

Supplemental Table 9. Study quality summary.

Characteristic		
Study, No. (%), N = 68 studies		
Prospective	52	(76.5)
Retrospective	16	(23.5)
Contributing centers, No. (%), N = 68 studies		
Single center	63	(92.6)
Multicenter	5	(7.4)
Study type, No. (%), N = 68 studies		
Comparative	13	(19.1)
Non-comparative	52	(76.5)
Randomised	2	(2.9)
Single cohort after primary endpoint of RCT	1	(1.5)
MINORS score, non-comparative, No. (%), N = 53 studies		
Poor quality (≤8)	8	(15.1)
Moderate quality (9-14)	45	(84.9)
Good quality (15-16)	0	(0.0)
MINORS score, non-comparative, median (interquartile range)	10	(9 to 11)
MINORS score, non-comparative, mean (standard deviation)	9.8	(1.4)
MINORS score, comparative studies, No. (%), N = 15 studies		
Poor quality (≤14)	11	(73.3)
Moderate quality (15-22)	3	(20.0)
Good quality (23-24)	1	(6.7)
MINORS score, comparative, median (interquartile range)	13	(12 to 15)
MINORS score, comparative, mean (standard deviation)	14.1	(3.7)
Level of evidence score, No. (%), N = 68 studies		
1	2	(2.9)
2	10	(14.7)
3	3	(4.4)
4	53	(77.9)
5	0	(0.0)
Level of evidence score, comparative, median (interquartile range)	4	(4 to 4)
Level of evidence score, comparative, mean (standard deviation)	3.6	(0.9)

Supplemental Table 10. I^2 statistics.

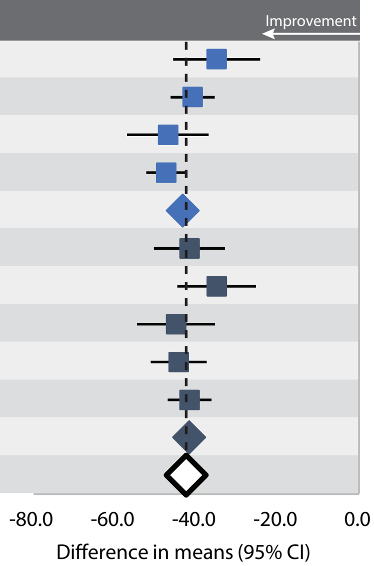
Analysis	3 months		6 months		12 months	
	WMD (95% CI) [a]	I^2 (95% CI)	WMD (95% CI) [a]	I^2 (95% CI)	WMD (95% CI) [a]	I^2 (95% CI)
Nasal valve treatment						
TCRF	−43.3 (−48.3 to −38.3)	51.5% (0.0% to 84.0%)	−49.3 (−61.8 to −36.7)	86.7% (47.6% to 96.6%)	−48.8 (−56.9 to −40.7)	67.9% (0.0% to 92.7%)
Rhinoplasty	−41.9 (−45.2 to −38.6)	0.0% (0.0% to 79.2%)	−40.4 (−47.5 to −33.3)	93.8% (90.2% to 96.0%)	−48.8 (−56.5 to −41.1)	85.1% (71.2% to 92.3%)
Combined	−42.7 (−45.4 to −40.1)	17.7% (0.0% to 59.6%)	−42.1 (−48.4 to −35.8)	92.8% (89.1% to 95.3%)	−48.9 (−54.8 to −42.9)	81.8% (66.5% to 90.1%)
Without turbinate treatment						
TCRF	−43.3 (−48.3 to −38.3)	51.5% (0.0% to 84.0%)	−49.3 (−61.8 to −36.7)	86.7% (47.6% to 96.6%)	−48.8 (−56.9 to −40.7)	67.9% (0.0% to 92.7%)
Rhinoplasty	−44.4 (−48.9 to −39.9)	92.0% (88.8% to 94.2%)	−43.4 (−46.6 to −40.3)	90.7% (87.9% to 92.9%)	−45.3 (−49.1 to −41.4)	80.9% (71.7% to 87.1%)
Combined	−44.1 (−48.0 to −40.3)	90.3% (86.7% to 93.0%)	−43.8 (−46.9 to −40.8)	90.4% (87.6% to 92.6%)	−45.6 (−49.1 to −42.1)	80.2% (71.0% to 86.5%)
All						
TCRF	−43.3 (−48.3 to −38.3)	51.5% (0.0% to 84.0%)	−49.3 (−61.8 to −36.7)	86.7% (47.6% to 96.6%)	−48.8 (−56.9 to −40.7)	67.9% (0.0% to 92.7%)
Rhinoplasty	−47.1 (−50.4 to −43.8)	92.0% (89.9% to 93.7%)	−42.9 (−45.8 to −40.0)	91.1% (88.9% to 92.9%)	−47.7 (−51.1 to −44.4)	90.0% (87.2% to 92.2%)
Combined	−46.6 (−49.6 to −43.6)	91.2% (88.9% to 93.1%)	−43.2 (−46.0 to −40.4)	90.9% (88.6% to 92.7%)	−47.8 (−51.0 to −44.6)	89.5% (86.6% to 91.8%)

[a] Data are reported in Table 2. Weighted mean difference (WMD) in nasal obstruction symptom evaluation (NOSE) score between baseline and follow-up with 95% confidence interval. Weights are from random-effects model.

Supplemental Figure 1. Forest plots, nasal valve treatment only analyses.

3 months

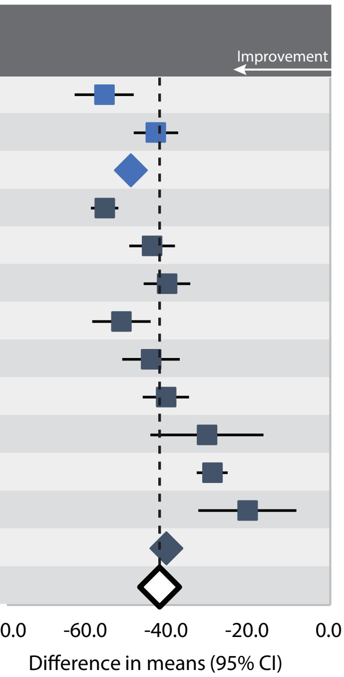
Source	Difference in means (95% CI)	Weight
Brehmer et al. [21] 2019	−35.0 (−45.7 to −24.3)	15.5%
Han et al. [25] 2022	−40.9 (−46.3 to −35.5)	32.5%
Wu et al. [23] 2021	−47.0 (−57.0 to −37.0)	17.0%
Yao et al. [24] 2021	−47.4 (−52.3 to −42.5)	34.9%
TCRF treatment (WMD)	**−43.3 (−48.3 to −38.3)**	**100%**
Chambers et al. [36] 2015	−41.7 (−50.4 to −33.0)	14.5%
Dolan et al. [39] 2010	−35.0 (−44.7 to −25.3)	11.9%
Hismi et al. [52] 2022 i	−45.0 (−54.6 to −35.4)	12.1%
Hismi et al. [52] 2022 ii	−44.3 (−51.2 to −37.5)	23.6%
Hismi et al. [52] 2022 iii	−41.7 (−47.1 to −36.3)	38.0%
Rhinoplasty surgery (WMD)	**−41.9 (−45.2 to −38.6)**	**100%**
Overall (WMD)	**−42.7 (−45.4 to −40.1)**	**100%**



Supplemental Figure 1 *continued*. Forest plots, nasal valve treatment only analyses.

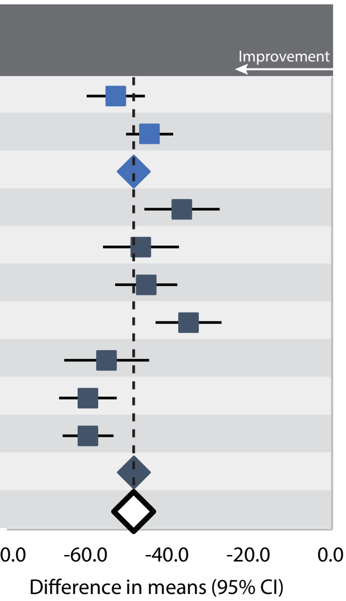
6 months

Source	Difference in means (95% CI)	Weight
Ephrat et al. [22] 2021	−55.9 (−63.2 to −48.6)	48.2%
Han et al. [25] 2022	−43.1 (−48.6 to −37.6)	51.8%
TCRF treatment (WMD)	**−49.3 (−61.8 to −36.7)**	**100%**
Aladag et al. [27] 2019	−55.8 (−59.2 to −52.4)	12.3%
Burks et al. [34] 2022	−44.1 (−49.8 to −38.4)	11.7%
Burks et al. [34] 2022	−40.4 (−46.2 to −34.6)	11.7%
Hismi et al. [52] 2022 i	−51.7 (−58.9 to −44.4)	11.2%
Hismi et al. [52] 2022 ii	−44.3 (−51.4 to −37.2)	11.3%
Hismi et al. [52] 2022 iii	−40.7 (−46.4 to −35.0)	11.7%
Palesy et al. [66] 2015	−30.5 (−44.5 to −16.5)	8.5%
Weitzman et al. [82] 2021 i	−29.2 (−33.0 to −25.4)	12.2%
Weitzman et al. [82] 2021 ii	−20.5 (−32.6 to −8.4)	9.3%
Rhinoplasty surgery (WMD)	**−40.4 (−47.5 to −33.3)**	**100%**
Overall (WMD)	**−42.1 (−48.4 to −35.8)**	**100%**



12 months

Source	Difference in means (95% CI)	Weight
Ephrat et al. [22] 2021	−53.2 (−60.4 to −46.0)	46.6%
Han et al. [25] 2022	−44.9 (−50.7 to −39.1)	53.4%
TCRF treatment (WMD)	**−48.8 (−56.9 to −40.7)**	**100%**
Abdelwahab et al. [26] 2021	−36.9 (−46.2 to −27.7)	13.8%
Hismi et al. [52] 2022 i	−47.0 (−56.4 to −37.6)	13.7%
Hismi et al. [52] 2022 ii	−45.7 (−53.3 to −38.0)	14.7%
Hismi et al. [52] 2022 iii	−35.3 (−43.4 to −27.2)	14.4%
Islam et al. [55] 2008	−55.5 (−65.9 to −45.0)	13.1%
Tan et al. [76] 2012	−60.0 (−67.1 to −52.9)	15.0%
Tastan et al. [77] 2011	−60.0 (−66.3 to −53.7)	15.4%
Rhinoplasty surgery (WMD)	**−48.8 (−56.5 to −41.1)**	**100%**
Overall (WMD)	**−48.9 (−54.8 to −42.9)**	**100%**

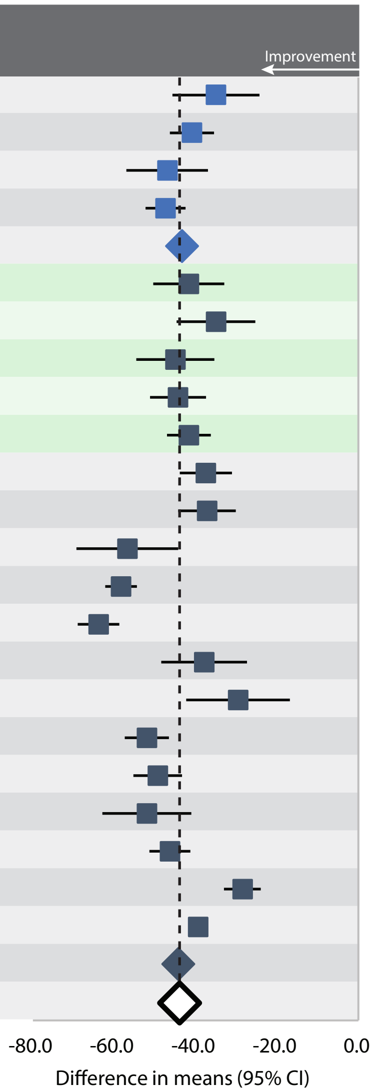


Difference in nasal obstruction symptom evaluation (NOSE) score between baseline and follow-up timepoint. 95% CI, 95% confidence interval; WMD, weighted mean difference. Weights are from random-effects analysis (for group-level analyses).

Supplemental Figure 2. Forest plots, without concomitant turbinate treatment analyses.

3 months

Source	Difference in means (95% CI)	Weight
Brehmer et al. [21] 2019	−35.0 (−45.7 to −24.3)	15.5%
Han et al. [25] 2022	−40.9 (−46.3 to −35.5)	32.5%
Wu et al. [23] 2021	−47.0 (−57.0 to −37.0)	17.0%
Yao et al. [24] 2021	−47.4 (−52.3 to −42.5)	34.9%
TCRF treatment (WMD)	**−43.3 (−48.3 to −38.3)**	**100%**
Chambers et al. [36] 2015	−41.7 (−50.4 to −33.0)	5.3%
Dolan et al. [39] 2010	−35.0 (−44.7 to −25.3)	5.1%
Hismi et al. [52] 2022 i	−45.0 (−54.6 to −35.4)	5.1%
Hismi et al. [52] 2022 ii	−44.3 (−51.2 to −37.5)	5.7%
Hismi et al. [52] 2022 iii	−41.7 (−47.1 to −36.3)	6.0%
Andrews et al. [30] 2015	−37.5 (−43.9 to −31.1)	5.8%
Datema et al. [37] 2017	−37.2 (−43.0 to −31.4)	5.7%
de Moura et al. [38] 2018 ii	−56.8 (−69.3 to −44.3)	4.4%
Gökçe Kütük et al. [47] 2019	−58.3 (−62.2 to −54.4)	6.3%
Gökçe Kütük et al. [48] 2022	−63.9 (−69.0 to −58.8)	6.1%
Günel et al. [50] 2015 i	−37.9 (−48.5 to −27.4)	4.9%
Günel et al. [50] 2015 ii	−29.6 (−42.3 to −16.8)	4.3%
Kandathil et al. [57] 2021	−52.0 (−57.4 to −46.6)	6.0%
Kandathil et al. [58] 2021	−49.3 (−55.3 to −43.3)	5.9%
Lavinsky-Wolff et al. [60] 2013 ii	−52.0 (−62.9 to −41.1)	4.8%
Sahin et al. [71] 2016	−46.4 (−51.4 to −41.3)	6.1%
Shafik et al. [73] 2020	−28.5 (−33.0 to −24.0)	6.2%
Yamasaki et al. [84] 2019 i	−39.4 (−41.5 to −37.3)	6.5%
Rhinoplasty surgery (WMD)	**−44.4 (−48.9 to −39.9)**	**100%**
Overall (WMD)	**−44.1 (−48.0 to −40.3)**	**100%**

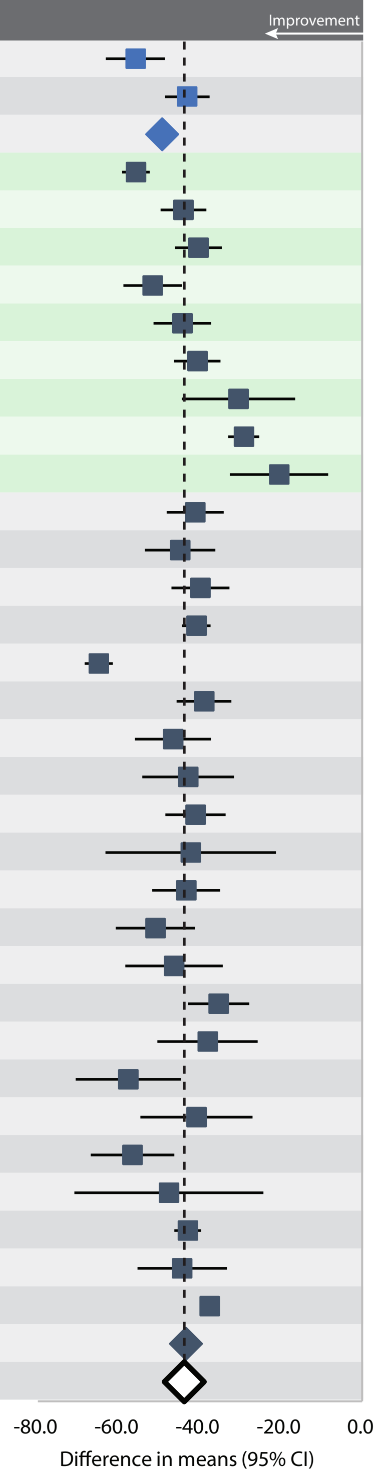


Difference in nasal obstruction symptom evaluation (NOSE) score between baseline and follow-up timepoint. 95% CI, 95% confidence interval; WMD, weighted mean difference. Green shading indicates datasets included in nasal valve surgery analyses.

Supplemental Figure 2 *continued*. Forest plots, without concomitant turbinate treatment analyses.

6 months

Source	Difference in means (95% CI)	Weight
Ephrat et al. [22] 2021	−55.9 (−63.2 to −48.6)	48.2%
Han et al. [25] 2022	−43.1 (−48.6 to −37.6)	51.8%
TCRF treatment (WMD)	**−49.3 (−61.8 to −36.7)**	**100%**
Aladag et al. [27] 2019	−55.8 (−59.2 to −52.4)	4.1%
Burks et al. [34] 2022	−44.1 (−49.8 to −38.4)	3.8%
Burks et al. [34] 2022	−40.4 (−46.2 to −34.6)	3.8%
Hismi et al. [52] 2022 i	−51.7 (−58.9 to −44.4)	3.5%
Hismi et al. [52] 2022 ii	−44.3 (−51.4 to −37.2)	3.5%
Hismi et al. [52] 2022 iii	−40.7 (−46.4 to −35.0)	3.8%
Palesy et al. [66] 2015	−30.5 (−44.5 to −16.5)	2.3%
Weitzman et al. [82] 2021 i	−29.2 (−33.0 to −25.4)	4.1%
Weitzman et al. [82] 2021 ii	−20.5 (−32.6 to −8.4)	2.6%
Fuller et al. [42] 2017	−41.2 (−48.2 to −34.2)	3.6%
Fuller et al. [43] 2017	−44.9 (−53.6 to −36.2)	3.3%
Fuller et al. [44] 2019	−39.9 (−47.0 to −32.8)	3.5%
Fuller et al. [45] 2019	−40.9 (−44.4 to −37.4)	4.1%
Gökçe Kütük et al. [47] 2019	−65.0 (−68.5 to −61.5)	4.1%
Goudakos et al. [49] 2017	−39.0 (−45.8 to −32.2)	3.6%
Günel et al. [50] 2015 i	−46.7 (−56.0 to −37.3)	3.1%
Günel et al. [50] 2015 ii	−42.9 (−54.2 to −31.6)	2.8%
Hismi et al. [51] 2020	−41.1 (−48.6 to −33.6)	3.5%
Justicz et al. [56] 2019 i	−42.3 (−63.3 to −21.3)	1.5%
Justicz et al. [56] 2019 ii	−43.4 (−51.8 to −35.0)	3.3%
Kandathil et al. [57] 2021	−51.0 (−60.8 to −41.2)	3.1%
Kandathil et al. [58] 2021	−46.4 (−58.4 to −34.4)	2.7%
Kaura et al. [59] 2019	−35.4 (−43.0 to −27.8)	3.5%
Lindsay et al. [61] 2012 i	−38.1 (−50.5 to −25.8)	2.6%
Lindsay et al. [61] 2012 ii	−57.7 (−70.7 to −44.7)	2.5%
Lindsay et al. [61] 2012 ii	−40.8 (−54.7 to −27.0)	2.4%
Nural et al. [65] 2019	−56.7 (−6.07 to −46.3)	3.0%
Pecorari et al. [67] 2017	−47.7 (−71.0 to −24.3)	1.3%
Weitzman et al. [83] 2022 i	−43.0 (−46.3 to −39.7)	4.1%
Weitzman et al. [83] 2022 ii	−44.4 (−55.4 to −33.4)	2.8%
Yamasaki et al. [84] 2019 i	−37.6 (−40.0 to −35.2)	4.2%
Rhinoplasty surgery (WMD)	**−43.4 (−46.6 to −40.3)**	**100%**
Overall (WMD)	**−43.8 (−46.9 to −40.8)**	**100%**

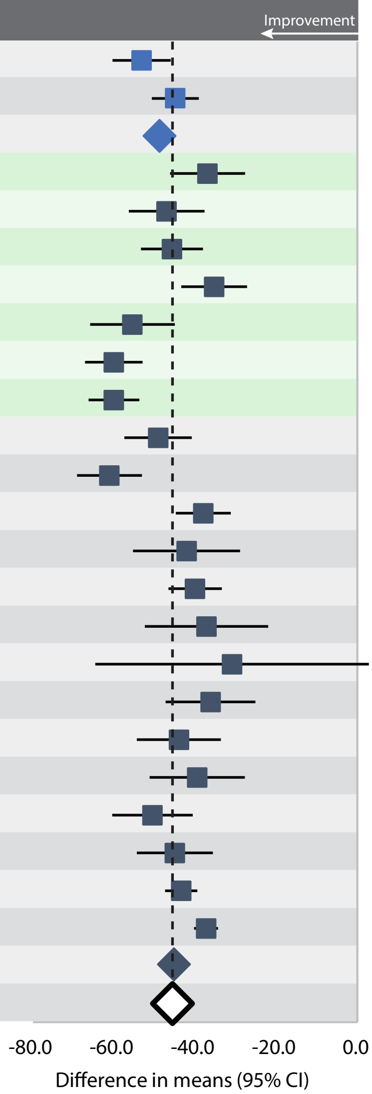


Difference in nasal obstruction symptom evaluation (NOSE) score between baseline and follow-up timepoint. 95% CI, 95% confidence interval; WMD, weighted mean difference. Green shading indicates datasets included in nasal valve surgery analyses.

Supplemental Figure 2 *continued*. Forest plots, without concomitant turbinate treatment analyses.

12 months

Source	Difference in means (95% CI)	Weight
Ephrat et al. [22] 2021	−53.2 (−60.4 to −46.0)	46.6%
Han et al. [25] 2022	−44.9 (−50.7 to −39.1)	53.4%
TCRF treatment (WMD)	**−48.8 (−56.9 to −40.7)**	**100%**
Abdelwahab et al. [26] 2021	−36.9 (−46.2 to −27.7)	4.8%
Hismi et al. [52] 2022 i	−47.0 (−56.4 to −37.6)	4.8%
Hismi et al. [52] 2022 ii	−45.7 (−53.3 to −38.0)	5.3%
Hismi et al. [52] 2022 iii	−35.3 (−43.4 to −27.2)	5.1%
Islam et al. [55] 2008	−55.5 (−65.9 to −45.0)	4.5%
Tan et al. [76] 2012	−60.0 (−67.1 to −52.9)	5.4%
Tastan et al. [77] 2011	−60.0 (−66.3 to −53.7)	5.7%
Albergo et al. [29] 2020	−49.1 (−57.4 to −40.8)	5.1%
Başer et al. [32] 2016	−61.1 (−69.1 to −53.1)	5.2%
Datema et al. [37] 2017	−38.0 (−44.8 to −31.2)	5.5%
Fuller et al. [43] 2017	−42.1 (−55.3 to −28.9)	3.7%
Goudakos et al. [49] 2017	−40.0 (−46.6 to −33.4)	5.6%
Hismi et al. [51] 2020	−37.2 (−52.4 to −22.0)	3.2%
Justicz et al. [56] 2019 i	−30.9 (−64.6 to 2.8)	1.1%
Justicz et al. [56] 2019 ii	−36.2 (−47.3 to −25.1)	4.3%
Kandathil et al. [57] 2021	−44.0 (−54.3 to −33.7)	4.5%
Kandathil et al. [58] 2021	−39.5 (−51.2 to −27.8)	4.1%
Radulesco et al. [68] 2018	−50.5 (−60.4 to −40.6)	4.6%
Tugrul et al. [79] 2019	−45.0 (−54.4 to −35.6)	4.8%
van Zijl et al. [81] 2022	−43.4 (−47.4 to −39.4)	6.3%
Yamasaki et al. [84] 2019 i	−37.3 (−40.3 to −34.3)	6.4%
Rhinoplasty surgery (WMD)	**−45.3 (−49.1 to −41.4)**	**100%**
Overall (WMD)	**−45.6 (−49.1 to −42.1)**	**100%**

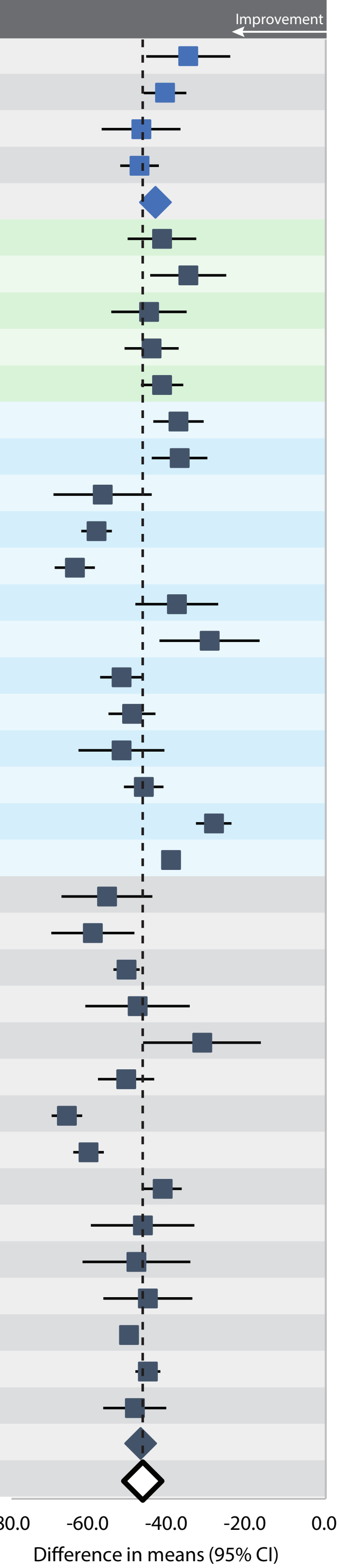


Difference in nasal obstruction symptom evaluation (NOSE) score between baseline and follow-up timepoint. 95% CI, 95% confidence interval; WMD, weighted mean difference. Green shading indicates datasets included in nasal valve surgery analyses.

Supplemental Figure 3. Forest plots, all procedures analyses.

3 months

Source	Difference in means (95% CI)	Weight
Brehmer et al. [21] 2019	−35.0 (−45.7 to −24.3)	15.5%
Han et al. [25] 2022	−40.9 (−46.3 to −35.5)	32.5%
Wu et al. [23] 2021	−47.0 (−57.0 to −37.0)	17.0%
Yao et al. [24] 2021	−47.4 (−52.3 to −42.5)	34.9%
TCRF treatment (WMD)	**−43.3 (−48.3 to −38.3)**	**100%**
Chambers et al. [36] 2015	−41.7 (−50.4 to −33.0)	2.9%
Dolan et al. [39] 2010	−35.0 (−44.7 to −25.3)	2.8%
Hismi et al. [52] 2022 i	−45.0 (−54.6 to −35.4)	2.8%
Hismi et al. [52] 2022 ii	−44.3 (−51.2 to −37.5)	3.2%
Hismi et al. [52] 2022 iii	−41.7 (−47.1 to −36.3)	3.4%
Andrews et al. [30] 2015	−37.5 (−43.9 to −31.1)	3.2%
Datema et al. [37] 2017	−37.2 (−43.0 to −31.4)	3.2%
de Moura et al. [38] 2018 ii	−56.8 (−69.3 to −44.3)	2.4%
Gökçe Kütük et al. [47] 2019	−58.3 (−62.2 to −54.4)	3.5%
Gökçe Kütük et al. [48] 2022	−63.9 (−69.0 to −58.8)	3.4%
Günel et al. [50] 2015 i	−37.9 (−48.5 to −27.4)	2.7%
Günel et al. [50] 2015 ii	−29.6 (−42.3 to −16.8)	2.4%
Kandathil et al. [57] 2021	−52.0 (−57.4 to −46.6)	3.4%
Kandathil et al. [58] 2021	−49.3 (−55.3 to −43.3)	3.3%
Lavinsky-Wolff et al. [60] 2013 ii	−52.0 (−62.9 to −41.1)	2.6%
Sahin et al. [71] 2016	−46.4 (−51.4 to −41.3)	3.4%
Shafik et al. [73] 2020	−28.5 (−33.0 to −24.0)	3.5%
Yamasaki et al. [84] 2019 i	−39.4 (−41.5 to −37.3)	3.7%
Alan et al. [28] 2022 i	−55.7 (−67.2 to −44.2)	2.5%
Alan et al. [28] 2022 ii	−59.3 (−69.9 to −48.7)	2.7%
Andrews et al. [31] 2021	−50.7 (−54.1 to −47.3)	3.6%
de Moura et al. [38] 2018 i	−47.9 (−61.2 to −34.6)	2.3%
Erickson et al. [41] 2016	−31.5 (−46.5 to −16.5)	2.1%
Gerecci et al. [46] 2019	−50.8 (−58.0 to −43.6)	3.2%
Inan et al. [53] 2022 i	−65.9 (−69.8 to −62.0)	3.5%
Inan et al. [53] 2022 ii	−60.4 (−64.3 to −56.5)	3.5%
İnan et al. [54] 2022	−41.5 (−46.4 to −36.6)	3.4%
Lavinsky-Wolff et al. [60] 2013 i	−46.6 (−59.8 to −33.4)	2.3%
Rhee et al. [69] 2005	−48.2 (−61.9 to −34.5)	2.2%
Vaezeafshar et al. [80] 2018	−45.3 (−56.6 to −34.0)	2.6%
Yamasaki et al. [84] 2019 ii	−50.1 (−52.4 to −47.8)	3.6%
Yamasaki et al. [85] 2020	−45.3 (−48.5 to −42.1)	3.6%
Yeung et al. [86] 2016	−48.6 (−56.6 to −40.6)	3.0%
Rhinoplasty surgery (WMD)	**−47.1 (−50.4 to −43.8)**	**100%**
Overall (WMD)	**−46.6 (−49.6 to −43.6)**	**100%**

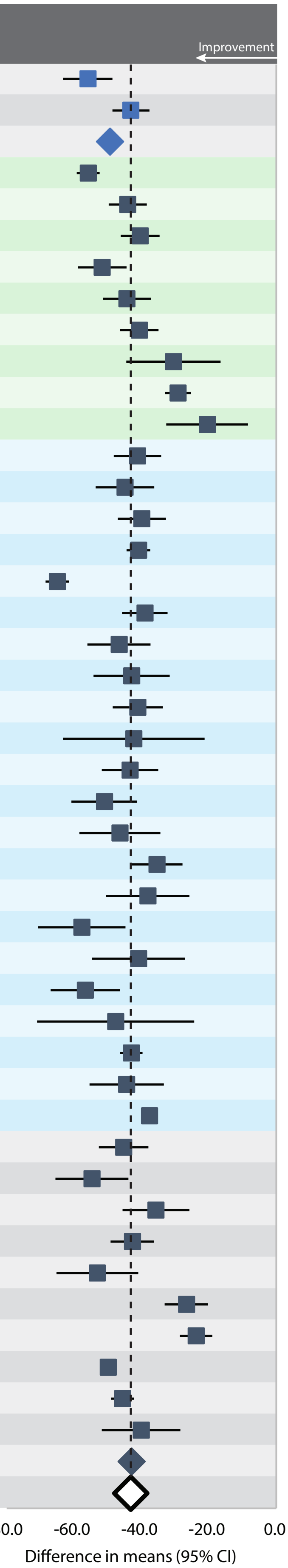


Difference in nasal obstruction symptom evaluation (NOSE) score between baseline and follow-up timepoint. 95% CI, 95% confidence interval; WMD, weighted mean difference. Green shading indicates datasets included in nasal valve surgery analyses. Blue shading indicated datasets included in functional rhinoplasty without concomitant turbinate treatment analyses.

Supplemental Figure 3 *continued*.
Forest plots, all procedures analyses.

6 months

Source	Difference in means (95% CI)	Weight
Ephrat et al. [22] 2021	−55.9 (−63.2 to −48.6)	48.2%
Han et al. [25] 2022	−43.1 (−48.6 to −37.6)	51.8%
TCRF treatment (WMD)	**−49.3 (−61.8 to −36.7)**	**100%**
Aladag et al. [27] 2019	−55.8 (−59.2 to −52.4)	3.0%
Burks et al. [34] 2022	−44.1 (−49.8 to −38.4)	2.8%
Burks et al. [34] 2022	−40.4 (−46.2 to −34.6)	2.8%
Hismi et al. [52] 2022 i	−51.7 (−58.9 to −44.4)	2.6%
Hismi et al. [52] 2022 ii	−44.3 (−51.4 to −37.2)	2.6%
Hismi et al. [52] 2022 iii	−40.7 (−46.4 to −35.0)	2.8%
Palesy et al. [66] 2015	−30.5 (−44.5 to −16.5)	1.8%
Weitzman et al. [82] 2021 i	−29.2 (−33.0 to −25.4)	3.0%
Weitzman et al. [82] 2021 ii	−20.5 (−32.6 to −8.4)	2.0%
Fuller et al. [42] 2017	−41.2 (−48.2 to −34.2)	2.6%
Fuller et al. [43] 2017	−44.9 (−53.6 to −36.2)	2.4%
Fuller et al. [44] 2019	−39.9 (−47.0 to −32.8)	2.6%
Fuller et al. [45] 2019	−40.9 (−44.4 to −37.4)	3.0%
Gökçe Kütük et al. [47] 2019	−65.0 (−68.5 to −61.5)	3.0%
Goudakos et al. [49] 2017	−39.0 (−45.8 to −32.2)	2.7%
Günel et al. [50] 2015 i	−46.7 (−56.0 to −37.3)	2.4%
Günel et al. [50] 2015 ii	−42.9 (−54.2 to −31.6)	2.1%
Hismi et al. [51] 2020	−41.1 (−48.6 to −33.6)	2.6%
Justicz et al. [56] 2019 i	−42.3 (−63.3 to −21.3)	1.2%
Justicz et al. [56] 2019 ii	−43.4 (−51.8 to −35.0)	2.5%
Kandathil et al. [57] 2021	−51.0 (−60.8 to −41.2)	2.3%
Kandathil et al. [58] 2021	−46.4 (−58.4 to −34.4)	2.0%
Kaura et al. [59] 2019	−35.4 (−43.0 to −27.8)	2.6%
Lindsay et al. [61] 2012 i	−38.1 (−50.5 to −25.8)	2.0%
Lindsay et al. [61] 2012 ii	−57.7 (−70.7 to −44.7)	1.9%
Lindsay et al. [61] 2012 ii	−40.8 (−54.7 to −27.0)	1.8%
Nural et al. [65] 2019	−56.7 (−6.07 to −46.3)	2.2%
Pecorari et al. [67] 2017	−47.7 (−71.0 to −24.3)	1.0%
Weitzman et al. [83] 2022 i	−43.0 (−46.3 to −39.7)	3.0%
Weitzman et al. [83] 2022 ii	−44.4 (−55.4 to −33.4)	2.1%
Yamasaki et al. [84] 2019 i	−37.6 (−40.0 to −35.2)	3.1%
Calloway et al. [35] 2019	−45.3 (−52.6 to −38.0)	2.6%
Loyo et al. [62] 2016	−54.7 (−65.6 to −43.8)	2.2%
Martin et al. [63] 2022	−35.7 (−45.6 to −25.8)	2.3%
Most et al. [64] 2006	−42.7 (−49.2 to −36.2)	2.7%
Rhee et al. [69] 2005	−53.1 (−65.2 to −41.0)	2.0%
Rudes et al. [70] 2018	−26.7 (−33.1 to −20.2)	2.7%
Tjahjono et al. [78] 2019	−23.8 (−28.6 to −18.9)	2.9%
Yamasaki et al. [84] 2019 ii	−49.9 (−52.3 to −47.5)	3.1%
Yamasaki et al. [85] 2020	−45.6 (−49.0 to −42.2)	3.0%
Yoo et al. [87] 2011	−40.1 (−51.7 to −28.5)	2.1%
Rhinoplasty surgery (WMD)	**−42.9 (−45.8 to −40.0)**	**100%**
Overall (WMD)	**−43.2 (−46.0 to −40.4)**	**100%**

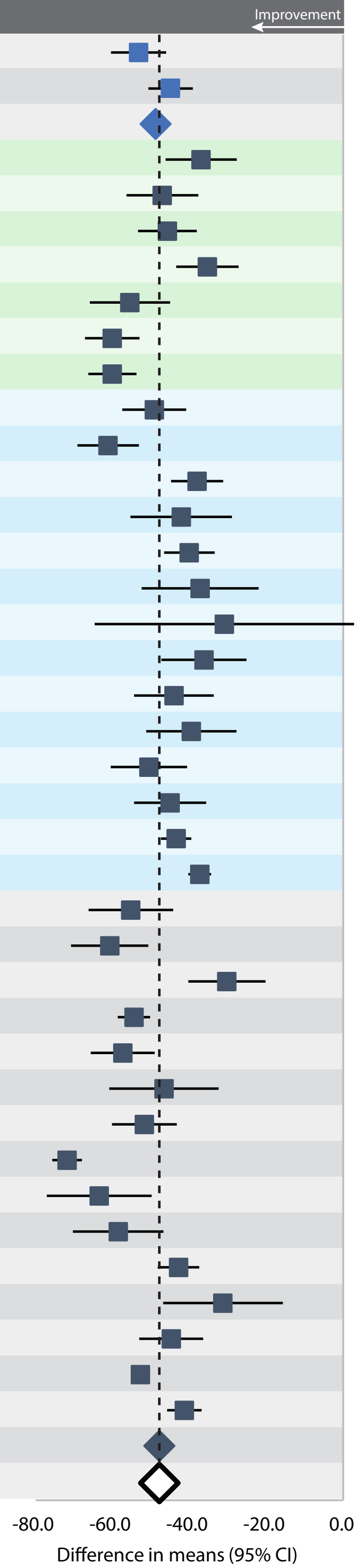


Difference in nasal obstruction symptom evaluation (NOSE) score between baseline and follow-up timepoint. 95% CI, 95% confidence interval; WMD, weighted mean difference. Green shading indicates datasets included in nasal valve surgery analyses. Blue shading indicated datasets included in functional rhinoplasty without concomitant turbinate treatment analyses.

Supplemental Figure 3 *continued*. Forest plots, all procedures analyses.

12 months

Source	Difference in means (95% CI)	Weight
Ephrat et al. [22] 2021	−53.2 (−60.4 to −46.0)	46.6%
Han et al. [25] 2022	−44.9 (−50.7 to −39.1)	53.4%
TCRF treatment (WMD)	**−48.8 (−56.9 to −40.7)**	**100%**
Abdelwahab et al. [26] 2021	−36.9 (−46.2 to −27.7)	2.8%
Hismi et al. [52] 2022 i	−47.0 (−56.4 to −37.6)	2.8%
Hismi et al. [52] 2022 ii	−45.7 (−53.3 to −38.0)	3.0%
Hismi et al. [52] 2022 iii	−35.3 (−43.4 to −27.2)	2.9%
Islam et al. [55] 2008	−55.5 (−65.9 to −45.0)	2.6%
Tan et al. [76] 2012	−60.0 (−67.1 to −52.9)	3.1%
Tastan et al. [77] 2011	−60.0 (−66.3 to −53.7)	3.2%
Albergo et al. [29] 2020	−49.1 (−57.4 to −40.8)	2.9%
Başer et al. [32] 2016	−61.1 (−69.1 to −53.1)	3.0%
Datema et al. [37] 2017	−38.0 (−44.8 to −31.2)	3.1%
Fuller et al. [43] 2017	−42.1 (−55.3 to −28.9)	2.3%
Goudakos et al. [49] 2017	−40.0 (−46.6 to −33.4)	3.1%
Hismi et al. [51] 2020	−37.2 (−52.4 to −22.0)	2.1%
Justicz et al. [56] 2019 i	−30.9 (−64.6 to 2.8)	0.8%
Justicz et al. [56] 2019 ii	−36.2 (−47.3 to −25.1)	2.6%
Kandathil et al. [57] 2021	−44.0 (−54.3 to −33.7)	2.7%
Kandathil et al. [58] 2021	−39.5 (−51.2 to −27.8)	2.5%
Radulesco et al. [68] 2018	−50.5 (−60.4 to −40.6)	2.7%
Tugrul et al. [79] 2019	−45.0 (−54.4 to −35.6)	2.8%
van Zijl et al. [81] 2022	−43.4 (−47.4 to −39.4)	3.4%
Yamasaki et al. [84] 2019 i	−37.3 (−40.3 to −34.3)	3.5%
Alan et al. [28] 2022 i	−55.2 (−66.2 to −44.2)	2.6%
Alan et al. [28] 2022 ii	−60.7 (−70.7 to −50.7)	2.7%
Barham et al. [2] 2015	−30.3 (−40.3 to −20.2)	2.7%
Bessler et al. [33] 2015	−54.4 (−58.6 to −50.2)	3.4%
Eren et al. [40] 2014	−57.3 (−65.6 to −49.0)	2.9%
Loyo et al. [62] 2016	−46.6 (−60.8 to −32.4)	2.2%
Şahin et al. [72] 2022 i	−51.7 (−60.1 to −43.3)	2.9%
Şahin et al. [72] 2022 ii	−71.8 (−75.7 to −67.9)	3.4%
Sowder et al. [74] 2017 i	−63.4 (−77.0 to −49.8)	2.2%
Sowder et al. [74] 2017 ii	−58.5 (−70.3 to −46.7)	2.5%
Taha et al. [75] 2021 i	−42.8 (−48.2 to −37.4)	3.3%
Taha et al. [75] 2021 ii	−31.3 (−46.8 to −15.7)	2.0%
Vaezeafshar et al. [80] 2018	−44.7 (−53.0 to −36.4)	2.9%
Yamasaki et al. [84] 2019 ii	−52.7 (−55.2 to −50.2)	3.5%
Yamasaki et al. [85] 2020	−41.3 (−45.8 to −36.8)	3.3%
Rhinoplasty surgery (WMD)	**−47.7 (−51.1 to −44.4)**	**100%**
Overall (WMD)	**−47.8 (−51.0 to −44.6)**	**100%**



Difference in nasal obstruction symptom evaluation (NOSE) score between baseline and follow-up timepoint. 95% CI, 95% confidence interval; WMD, weighted mean difference. Green shading indicates datasets included in nasal valve surgery analyses. Blue shading indicated datasets included in functional rhinoplasty without concomitant turbinate treatment analyses.

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