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Comparative Efficacy of Suture-Based Techniques for Internal Nasal Valve Reconstruction: A Systematic Review

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Abstract

Objective

The internal nasal valve (INV) is the principal site of nasal airflow resistance. Cartilage grafting is the established correction; suture-based techniques are a conservative alternative with poorly defined comparative efficacy. We synthesised symptomatic, anatomic and durability outcomes of suture-based INV reconstruction in adults, stratified by intervention class.

Data Sources:

PubMed, Science Direct and the Cochrane Library were searched from inception to May 2026. Grey literature was retrieved through ProQuest (dissertations, theses, conference proceedings) and CENTRAL trial registrations, and reference lists were hand-screened.

Methods of Review:

The review was conducted following PRISMA 2020, Eligible studies enrolled ≥8 adults undergoing isolated or predominantly suture-based INV reconstruction. The risk of bias for each study was assessed using the Joanna Briggs Institute checklists and the Cochrane RoB 2.

Results:

Twelve studies (n = 471) were included. Across studies reporting paired NOSE data, preoperative scores of 65–75 fell to 11–28 (absolute reduction 45–64 points, 62–85%; all $p<0.05$), exceeding the 15–30-point minimal clinically important difference. Anatomic gains were concordant: minimal cross-sectional area +73–78%, INV angle +43–80%, peak inspiratory flow +59%.

Conclusions:

Suture-based INV reconstruction produced large, consistent symptomatic improvement with concordant anatomic gains across all three classes. These data support a phenotype-based choice that was tested prospectively.

Keywords: Internal nasal valve; Nasal valve collapse; Nasal obstruction; Suture suspension; Functional rhinoplasty; Nasal obstruction symptom evaluation (NOSE)

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Introduction

Nasal obstruction is among the most common otorhinolaryngological complaints in adults and is associated with measurable decrements in disease-specific quality of life, sleep quality, and daytime function (1,2). The internal nasal valve (INV) is defined by the angle between the caudal margin of the upper lateral cartilage and the dorsal nasal septum; it is the narrowest segment of the nasal airway and the principal site of static airflow resistance. Reported normative values for the INV angle in adult populations are approximately 10-15 degrees, with documented interpopulation anatomic variation (3,4).

Computational and physiological studies demonstrate a strong inverse relationship between minimal cross-sectional area at the valve and nasal airflow resistance, such that small reductions in valve dimensions produce disproportionately large increases in resistance (5,6). INV dysfunction may be static (anatomical narrowing) or dynamic (inspiratory lateral wall collapse), and frequently coexists with septal deviation, turbinate hypertrophy, or prior nasal surgery. Conventional surgical correction has relied on cartilage grafting techniques (spreader grafts, alar batten grafts, butterfly grafts and flaring grafts), which mechanically widen or stabilise the valve. Although graft-based approaches are established and effective, they incur donor-site morbidity from septal, conchal, or costal harvest; require additional operative time; may alter dorsal aesthetics through volumetric augmentation; and depend on the availability of suitable donor cartilage, which is particularly limited in revision rhinoplasty (7,8).

Suture-based reconstruction offers a structurally conservative alternative. Lateral nasal suspension sutures anchored to the piriform aperture, flaring sutures of the upper lateral cartilage, modified mattress sutures, and hybrid techniques combining suture suspension with limited grafting have all been described (9-11). The mechanical premise is direct lateral repositioning of the soft-tissue and cartilaginous lateral wall, without the volumetric augmentation of grafts. Theoretical advantages include preservation of native dorsal aesthetics, avoidance of donor-site morbidity, applicability in revision cases with depleted cartilage, and lower procedural cost. Three earlier reviews have surveyed this field. Spielmann et al. appraised 43 studies of nasal valve surgery published between 1970 and 2008. They found no randomised controlled trials, one study at level IIIb evidence, and validated outcome instruments in four reports. They concluded that the literature was driven more by descriptions of technique than by evidence of long-term patient benefit (8). Goudakos et al. searched four databases with extensive hand searching. They reached a similar verdict: 50 of 53 included studies were graded level IV, and the one randomised trial compared an autospreader flap against placebo without demonstrating a significant difference (12). Sinkler et al. later organised the operative repertoire narratively into cartilage grafts, implants and suspension sutures, setting out indications for each, but did not extract or compare outcome data (13).

None of the three isolated the suture-based subgroup, and none examined symptomatic, anatomic and durability outcomes side by side within it. We therefore synthesised studies of isolated and suture-augmented INV reconstruction in adults, reporting changes in validated symptom scores, objective airflow and imaging measures, perioperative safety, and long-term durability; appraising methodological quality; and integrating the results into a phenotype-stratified account of which approach suits which patient.

Materials and Methods

Protocol and registration

This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (14). The review was not prospectively registered; the protocol was documented in institutional records before commencement, and its key elements are reported here in accordance with PRISMA 2020. The absence of prospective registration is acknowledged as a limitation.

Eligibility criteria

Studies were included if they: (i) enrolled at least 8 adult patients (≥18 years), (ii) reported outcomes of isolated or predominantly suture-based INV reconstruction (including hybrid techniques in which suture suspension was the principal mechanical actor), and (iii) reported extractable preoperative and postoperative

validated symptom scores (NOSE, visual analog scale, Glasgow Benefit Inventory, or Rhinoplasty Outcome Evaluation), objective airflow measurements (acoustic rhinometry, rhinomanometry), or imaging-based valve metrics (computed-tomography valve angle or cross-sectional area).

The minimum sample size threshold was set at 8 to include foundational technique-defining series in this niche surgical literature while excluding individual case reports. Studies were excluded if they were case reports, conference abstracts without peer review, pediatric series, or interventions in which graft material was the principal mechanical actor.

Information sources and search strategy

A structured literature search was conducted in PubMed, Science Direct, the Cochrane Library and ProQuest from inception to May 2026. The search strategy combined controlled terms and free-text keywords: (“internal nasal valve” OR “nasal valve collapse” OR “nasal obstruction”) AND (“suture” OR “suspension” OR “lateralizing suture” OR “piriform” OR “flaring suture” OR “valve reconstruction”) as shown in (Table S1).

Table S1. Literature search strategy

Database	Keywords	Hits
Pubmed	(""internal nasal valve""[tiab] OR ""nasal valve collapse""[tiab] OR ""nasal valve stenosis""[tiab] OR ""nasal valve dysfunction""[tiab] OR ""nasal valve insufficiency""[tiab] OR ""nasal valve compromise""[tiab]) AND (""suture""[tiab] OR ""suspension""[tiab] OR ""lateralizing""[tiab] OR ""piriform""[tiab] OR ""flaring""[tiab] OR ""mattress""[tiab])	71
Cochrane	#1 MeSH descriptor: [Nasal Obstruction] explode all trees #2 MeSH descriptor: [Rhinoplasty] explode all trees #3 ("nasal valve" OR "internal nasal valve" OR "nasal valve collapse"):ti,ab,kw #4 ("suture" OR "suspension" OR "lateralizing" OR "piriform" OR "flaring" OR "mattress"):ti,ab,kw #5 (#1 OR #2 OR #3) AND #4	124
ScienceDirect	"all fields": ("internal nasal valve" OR "nasal valve collapse" OR "nasal valve stenosis" OR "nasal valve insufficiency") AND ("suture" OR "suspension suture" OR "lateralizing suture" OR "piriform" OR "flaring suture" OR "mattress suture") AND ("reconstruction" OR "repair" OR "correction" OR "surgery" OR "rhinoplasty")	529
ProQuest	TIAB(("internal nasal valve" OR "nasal valve collapse" OR "nasal valve dysfunction") AND (suture OR suspension OR lateralizing OR piriform OR flaring OR mattress))	3

Grey literature was searched by three routes. Restricting a review to the published record biases it towards positive results, because studies reporting positive findings are more likely to be submitted, accepted and indexed. First, the ProQuest search covered the Dissertations and Theses Global collection, along with indexed conference papers and proceedings, thereby enabling the identification of unpublished theses or articles. Second, registered trials were searched through the Cochrane Library, whose Central Register of Controlled Trials incorporates records drawn from Clinical Trials.gov and the WHO International Clinical Trials Registry Platform. Third, the reference lists of all included articles, the two prior systematic reviews (8,12), and one narrative review (13) were hand-screened for studies that the database searches had missed. No unpublished sources were eligible, and all 12 included studies are journal publications. Two constraints apply: manufacturer and device-registry reports were not searched, and conference abstracts that had not undergone peer review remained ineligible under the criteria in section 2.2. No language restriction was applied; one included study was published in Russian (24).Title/abstract and full-text screening were performed in duplicate, with discrepancies resolved by consensus.

Study selection

Records were de-duplicated and managed in Microsoft Excel. Title and abstract screening and full-text review were performed independently and in duplicate by two reviewers. Discrepancies were resolved by discussion or, when necessary, by consultation with a third reviewer.

Data extraction

Data were extracted independently by two reviewers using a standardised form.. Extracted variables included study design, country and

setting, sample size, age and sex distribution, surgical technique, concurrent procedures (septoplasty, turbinoplasty, rhinoplasty), follow-up duration, outcome instruments, pre- and postoperative outcome values with measures of dispersion, and adverse events. The protocol permitted standard deviations to be estimated from reported medians, ranges and interquartile ranges using the methods of Wan and colleagues (15) where a study did not report them directly, with a sensitivity analysis excluding any study so imputed. In this case, no study's data supported that step.

The Wan estimators recover the dispersion of a single distribution, whereas the quantity required here was the standard deviation of the paired within-patient change, which additionally requires the preoperative-to-postoperative correlation. No included study reported that correlation, or the paired differences from which it could be derived, and assuming a value would have made the effect sizes a function of the assumption rather than of the data. Imputation was therefore not performed, and every effect size reported below rests on directly reported means and standard deviations.

Risk-of-bias assessment

The methodological quality of the included primary studies was assessed independently by two reviewers using the Joanna Briggs Institute Critical Appraisal Checklist for Case Series (16). Domains assessed included the clarity of inclusion criteria, the validity of exposure measurement, the reliability of outcome measurement, the completeness of follow-up, and the appropriateness of statistical analysis. Disagreements were resolved by discussion. The two prior systematic reviews (8,12) and the narrative review (13) were used for citation tracking, contextualisation, and the comparison presented in section 4.5; they were not formally appraised, as they contributed no primary data to the synthesis.

The non-randomised comparative studies were appraised with the JBI Checklist for Quasi-Experimental Studies (16). For cross-study presentation, each domain was summarised on an ordinal low/moderate /high risk of bias; this tri-level summary is an adaptation introduced solely to allow a single comparable display across heterogeneous instruments, and the reliance on a harmonised ordinal summary rather than each tool's native output is acknowledged as a limitation. Randomised trials were assessed with the Cochrane RoB 2 tool across its five domains (17). Disagreements were resolved by discussion or, where necessary, by a third reviewer.

Synthesis methods

For studies reporting means and standard deviations for paired preoperative and postoperative NOSE scores, within-group standardised mean changes (Hedges's g) with 95% confidence intervals were calculated. Two studies met that requirement (20,28). Random-effects pooling with restricted maximum-likelihood estimation of between-study variance was prespecified but was not carried out. With two contributing effect estimates, the between-study variance cannot be estimated with useful precision, and the two studies differ in technique, concurrent surgery, and follow-up to a degree that would make a single summary difficult to interpret even if estimable. Individual effect sizes are therefore reported descriptively alongside absolute and relative score reductions.

Two secondary analyses were prespecified, and both are reported here as planned-but-uninformative rather than omitted. The first was a subgroup analysis by suture configuration, comparing pure-suture against suture-plus-graft constructs; as executed, it would have compared one study with another, yielding no interpretable contrast. The second was a sensitivity analysis in which any study contributing an imputed rather than a directly reported standard deviation would be removed, and the descriptive effect-size summary recomputed, so that the influence of imputation could be read directly.

It was executed as specified and returned the primary result unchanged because, for the reasons set out in section 2.5, no imputed standard deviation entered the synthesis. The set of excluded studies was empty, and the recomputed summary was identical to the primary summary. Publication bias was assessed as far as the available data permitted. Funnel-plot asymmetry and Egger regression require an adequate number of effect estimates with their standard errors; below roughly ten contributing studies both are so underpowered that a symmetric plot cannot be distinguished

from an asymmetric one, and the exercise invites over-reading (18).

Only two studies here yielded an effect estimate with a standard error.

A funnel plot of two points carries no information about small-study effects and was therefore not produced. The grey-literature component of the search, described in section 2.3, was the principal safeguard available, and the residual risk is stated in section 4.7.

Ethics

As this review analysed only previously published, aggregated data, institutional ethical approval was not required.

Results

Study selection

The PRISMA 2020 flow diagram of records identified, screened, retrieved, and included is presented in (Figure 1).

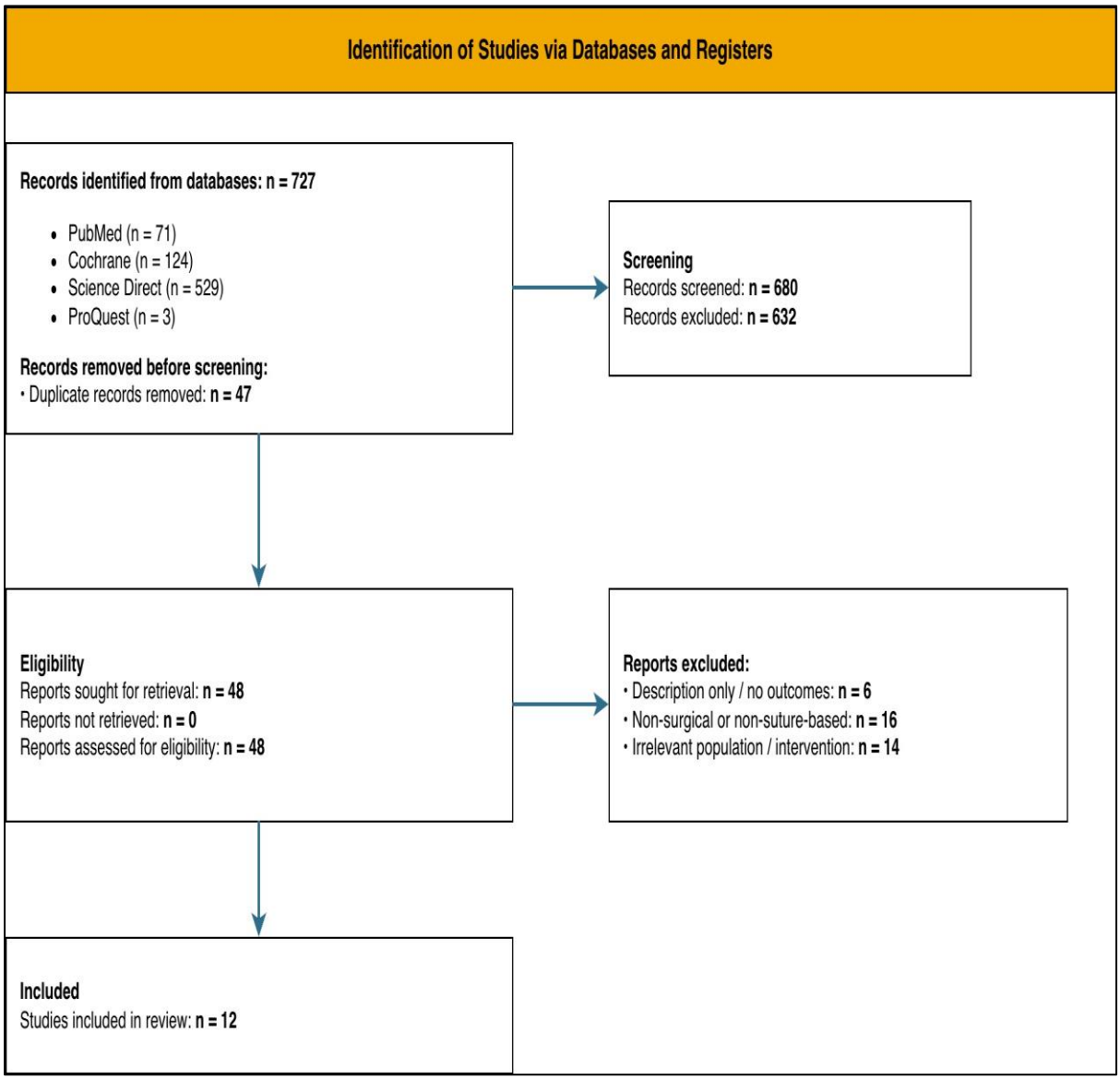

Fig 1: PRISMA flow diagram of search strategy

After deduplication, 680 records were screened by title and abstract; 48 full texts were retrieved; and twelve studies met inclusion criteria. Three prior systematic reviews (8,12,13) were retained for cross-reference checking and contextualization but were not included in quantitative synthesis.

Study characteristics

Characteristics of included studies are summarised in (Table 1).

Table 1. Characteristics of included studies

Study	n	Design	Technique	Concurrent procedures	Outcomes assessed	Follow-up
Lee & Glasgold; 2001 [9]	9	Prospective case series	Lateral nasal suspension suture	Not reported	Subjective symptom report	Short term
Rizvi & Gauthier, 2011 [17]	58	Retrospective cohort	Piriform-anchored lateral suspension, local anesthesia	Variable	Patient-reported maintained relief; technique failure	Up to 10 yr
Shin et al.; 2022 [18]	40	Prospective cohort	Modified mattress suture (high dorsal deviation correction)	Septoplasty + turbinoplasty in all	NOSE; CT INV angle and CSA	6–12 mo
Manickavasagam et al.; 2015 [19]	26	Retrospective case series	Alar suspension sutures (vestibular skin/lateral crura → inferior-orbital periosteum)	Concurrent cases excluded	VAS; PIFR	3, 6, 12 mo
André & Vuyk; 2008 [20]	20	Prospective case series	Valve suspension to infraorbital-rim periosteum	15/20 concurrent (septoplasty, turbinate, ethmoid)	Subjective 1–10 patency scale (per side); complications	Mean 5 mo (3–27)
Jalali; 2015[21]	133	Prospective comparative (semi-experimental)	Flaring suture (transverse dorsal mattress, ULC lateralization)	Primary rhinoplasty; 51 prior septoplasty	Nasal airway resistance (anterior rhinomanometry)	~21 wk
Sobolev et al.; 2015 [22]	29	Randomized comparative	Minimally invasive Aptos-thread suture suspension	Not specified	Modified (4–16) NOSE; aesthetic scale	1, 3, 12 mo
Islam et al.; 2008 [23]	11	Prospective case series	Modified endonasal splay graft + lateralizing suture	Variable	NOSE; acoustic rhinometry (MCA)	Up to 12 mo
Taştan et al.; 2011 [24]	19	Prospective case series	H-graft + lateralizing suture	Septoplasty in subset	VAS; ROE	12 mo
Manickavasagam et al.; 2014 [25]	39	Retrospective cohort	Composite suture + batten/butterfly/spreader graft as needed	Variable	GBI	Median 23 mo
Ismail et al., 2018 [26]	79	Prospective case series	Spreader graft + lateral suspension (flaring) sutures, open rhinoplasty	62 additional rhinoplasty; 17 conchal harvest	NOSE; endoscopic + CT INV angle	Up to 3 yr
Akyurek et al.; 2025 [27]	8	Retrospective case series	Modified dermal-fat flap suspension to lateral orbital rim, local anesthesia	None (revision; ≥2 prior surgeries)	NOSE (median/IQR)	Mean 9.3 mo

Abbreviations: NOSE, Nasal Obstruction Symptom Evaluation; VAS, visual analog scale; PIFR, peak inspiratory flow rate; ROE, Rhinoplasty Outcome Evaluation; GBI, Glasgow Benefit Inventory; MCA, minimum cross-sectional area; INV, internal nasal valve; CSA, cross-sectional area; CT, computed tomography; ULC, upper lateral cartilage.

Symptomatic outcomes

Outcome instruments and pre- and postoperative comparisons are summarised in (Table 2).

Table 2. Outcome instruments and pre- and postoperative values

Study	Instrument	Pre-operative	Post-operative	Comment
		Pure Suture		
Lee & Glasgold; 2001 [9]	Subjective report	Symptomatic obstruction	Improvement in 9/9 (100%)	No validated instrument
Rizvi & Gauthier; 2011 [17]	Patient-reported maintained relief	Symptomatic obstruction	89.9% maintained relief at up to 10 yr; 10.1% late failure	Survey-based long-term cohort
Shin et al.; 2022 [18]	NOSE	65.4	20.5	$p < 0.001$; concurrent septoplasty/turbinoplasty
Manickavasagam et al.; 2015 [19]	VAS (0–10); PIFR	VAS 7.7	VAS 2.9	Mean Δ VAS 4.97 (95% CI 4.48–5.46), $p < 0.001$; 90% satisfied
André & Vuyk; 2008 [20]	Subjective 1–10 patency (per side)	4.0/10 (avg)	6.3/10 (avg)	Avg Δ 2.3/10; per-side, no SD; ad-hoc scale; 25% complications, authors advise against first-line
Jalali; 2015 [21]	Rhinomanometry (no symptom score)	—	—	Objective airflow only; see Table 4. Preventive setting (no preop obstruction)
Sobolev et al.; 2015 [22]	Modified NOSE (4–16 scale)	12.1 ± 1.7	7.1 ± 3.1 (3 mo)	$p < 0.05$; simplified non-standard scale, not poolable with 0–100 NOSE; aesthetic outcome worst of 3 arms
		Hybrid: suture + structural cartilage graft		
Islam et al.; 2008 [23]	NOSE	≈75	≈11	$p < 0.05$
Taştan et al.; 2011 [24]	VAS / ROE	VAS: significant obstruction	VAS: significant improvement; ROE unchanged	Absolute VAS values not provided
Manickavasagam et al.; 2014 [25]	GBI (single instrument)	Not applicable	Median +56 (−100 to +100)	Substantial perceived benefit
Ismail et al.; 2018 [26]	NOSE	69.8 ± 8.7	20.65 ± 4.8	$p = 0.012$; 91% (72/79) sustained relief at ≥3 yr
		Hybrid: suture + autologous tissue flap		
Akyurek et al.; 2025 [27]	NOSE (median/IQR)	72.5 (IQR 70–85)	27.5 (IQR 22.5–32.5)	Between-arm vs spreader $p = 0.734$ (NS); local anesthesia; n = 8

Note: NOSE reported on the 0–100 transformed scale (higher = greater obstruction), except Sobolev, which used a simplified 4–16 Russian-adapted scale that cannot be pooled with standard NOSE. GBI is a single retrospective −100 to +100 instrument without separate pre/post values. Akyurek reported medians (IQR) because the data were non-normally distributed.

Table 3. Within-group effect sizes for paired NOSE outcomes (Across studies reporting paired NOSE data)

Study	Δ NOSE (absolute)	Δ NOSE (%)	Hedges g	Note
Pure suture				
Shin et al.; 2022 [18]	45 points	69%	3.7	Confounded by concurrent septoplasty/turbinoplasty
Hybrid: suture + structural cartilage graft				
Islam et al.; 2008 [23]	64 points	85%	4.8	Very small reported dispersion; interpret with caution
Ismail et al.; 20018 [23]	49.15 points	70.4%	≈ 6.9	Calculated from full-text Table 1 (pre 69.8 ± 8.7, post 20.65 ± 4.8, n = 79) using the same naive pooled-SD method; small SDs inflate g — read as direction/strength only
Hybrid: suture + autologous tissue flap				
Akyurek et al.; 2025 [27]	45 points (median)	≈62%	Not calculable	Median/IQR reported (non-normal distribution); means/SDs unavailable, so a standardized effect size cannot be computed

Note: Within-group standardized mean changes are descriptive and not comparable to between-arm standardized mean differences from controlled trials; formal random-effects pooling remains underpowered below the conventional threshold. Pure-suture studies other than Shin used VAS, PIFR, rhinomanometry, or categorical relief rather than NOSE and so do not appear here.

A verifiable Hedges' g could be computed for only two studies that reported NOSE means and standard deviations: 3.7 for a pure-suture study (20) and approximately 6.9 for a hybrid study (28). These values are within-arm pre-post quantities, not between-intervention effects; they lack a contemporaneous control, are inflated by very small reported dispersion, and should be read only as indicators of the direction and strength of change. The remaining studies either did not report dispersion or reported medians and interquartile ranges (the dermal-fat-flap study (29)), and therefore did not yield a standardised effect size. As prespecified, no quantitative pooling was performed, given the very small number of studies with extractable dispersion, marked clinical heterogeneity, and predominantly single-arm data.

Objective and imaging outcomes

Concordant anatomic improvements are summarised in (Table 4).

Table 4. Objective and imaging outcomes

Study	Modality	Metric	Pre-op	Post-op	% change (p)
Pure suture					
Shin et al.; 2022 [18]	CT	INV angle (°)	10.3	14.7	+43% (p < 0.001)
Shin et al.; 2022 [18]	CT	Valve cross-sectional area (mm²)	37.2	54.9	+47% (p < 0.001)
Manickavasagam; 2015 [19]	PIFR	Peak inspiratory flow (L/min)	40.29	64.15	+59% (Δ 25.5; p < 0.001)
Jalali; 2015 [21]	Anterior rhinomanometry	Nasal airway resistance — % of patients improved	baseline	84/133 (63.2%)	Median Δ 0.017 Pa/ml/s; p = 0.5 vs spreader
Hybrid: suture + structural cartilage graft					
Islam et al.; 2008 [23]	Acoustic rhinometry	Minimum cross-sectional area	baseline	increased	+73–78% (p = 0.003)
Ismail et al.; 2018 [26]	Endoscopy	INV angle (°) — right	7.23 ± 1.05	13.05 ± 0.91	+80.5% (p = 0.032)
Ismail et al.; 2018 [26]	Endoscopy	INV angle (°) — left	6.75 ± 1.34	11.89 ± 1.16	+76.1% (p = 0.019)
Ismail et al.; 2018 [26]	CT (axial)	INV angle (°) — right	8.11 ± 1.14	14.15 ± 1.17	+74.5% (p = 0.020)
Ismail et al.; 2018 [26]	CT (axial)	INV angle (°) — left	6.98 ± 1.03	12.13 ± 1.24	+73.8% (p = 0.015)

In Group 1, Shin et al. (20) demonstrated a 43% widening of the INV angle (10.3° to 14.7°) and a 47 per cent increase in valve cross-sectional area (37.2 to 54.9 mm²) on computed tomography (both p<0.001), and Manickavasagam et al. (21) reported a 59% increase in peak inspiratory flow (40.29 to 64.15 L/min, p < 0.001).

In Group 2, Islam et al. (25) documented a 73 to 78 per cent increase in minimal cross-sectional area on acoustic rhinometry (p = 0.003), and Ismail et al. (28) reported widening of the INV angle of 74 to 80 per cent on both endoscopy and computed tomography (all p < 0.05). The directional and proportional concordance between symptomatic and anatomic gains supports a mechanistic, rather than placebo, basis for the observed benefit.

Within-study comparative evidence

Three studies provided direct within-study comparisons against grafting. Jalali (23) compared a flaring suture with a spreader graft in primary-rhinoplasty patients without preoperative obstruction and found rhinomanometric resistance improved in 63% of the suture arm, with no statistically significant difference between arms (p = 0.5).

Akyurek et al. (29) compared a dermal-fat-flap suspension with a spreader graft in revision patients and found no significant difference in postoperative NOSE (median 27.5 versus 25; p = 0.734). In contrast, the three-arm randomised study by Sobolev et al. (24) reported that a spreader graft produced the best breathing and aesthetic outcomes, a local-tissue technique an intermediate result, and a minimally invasive thread suspension the least effective and least aesthetic result.

Long-term durability

Rizvi and Gauthier (19) reported the longest follow-up identified in this review for suture-based INV reconstruction, and among the

longest reported for any INV repair technique. In 58 patients undergoing piriform-anchored lateral suspension under local anaesthesia, 89.9% reported maintained symptomatic relief at follow-up of up to 10 years, while late technique failure attributable to suture cut-through or unravelling occurred in 10.1%, some of whom underwent revision. As single-cohort, survey-based, retrospective data, this durability estimate is of low certainty and requires prospective confirmation.

Safety

Perioperative complications were rare across most studies, affecting fewer than 5% of patients in aggregate and limited to transient crusting and minor suture irritation. The conspicuous exception was the infraorbital-rim suspension reported by André and Vuyk (22), which carried a 25% complication rate, including suborbital pain and swelling, re-exploration in three of twenty patients, and one permanent scar. In Group 3, transient periorbital oedema occurred in five of eight patients and one patient experienced six-month skin discolouration (29).

Risk of bias

Risk-of-bias assessment is summarised in Table S2 and S3. The three uniformly low-risk studies (25,26,28) all fell within Group 2, reflecting prospective design, validated, objective outcome measures, and complete follow-up. Within Group 1, Shin et al. (20) was rated low-to-moderate; Rizvi and Gauthier (19), Manickavasagam et al. (21) and Jalali (23) each carried at least one moderate domain, primarily reflecting retrospective design, non-validated instruments or comparative-arm assignment; Sobolev et al. (24), the only randomised trial, was rated low risk across all five RoB 2 domains (Table S3), its non-standard four-to-sixteen-point obstruction scale limiting comparability rather than internal validity; and Lee and Glasgold (9) and André and Vuyk (22) were rated moderate-to-high, reflecting the absence of validated instruments and, for the latter, an ad-hoc outcome scale without dispersion.

Table S2. Risk-of-bias assessment

Study	Inclusion criteria	Exposure measurement	Outcome measurement	Follow-up	Statistical analysis	Overall
Pure suture						
Lee & Glasgold; 2001 [9]	Moderate	Moderate	High	Moderate	Moderate	Moderate–High
Rizvi & Gauthier; 2011 [17]	Low	Moderate	Moderate	Low	Moderate	Moderate
Shin et al.; 2022 [18]	Low	Moderate	Low	Low	Low	Low–Moderate
Manickavasagam et al.; 2015 [19]	Moderate	Low	Moderate	Low	Low	Low–Moderate
André & Vuyk; 2008 [20]	Low	Low	Mod–High	Moderate	Mod–High	Moderate–High
Jalali; 2015[21]	Low–Mod	Low	Low	Moderate	Low	Low–Moderate
Hybrid: suture + structural cartilage graft						
Islam et al., 2008 [23]	Low	Low	Low	Low	Low	Low
Taştan et al., 2011 [24]	Low	Low	Low	Low	Low	Low
Manickavasagam et al.; 2014 [25]	Low	Moderate	Low	Low	Low	Moderate
Ismail et al.; 2018 [26]	Low	Low	Low	Low	Low	Low
Hybrid: suture + autologous tissue flap						
Akyurek et al.; 2025[27]	Moderate	Low	Moderate	Low–Mod	Low	Moderate

Table S3. Risk-of-bias assessment of the randomised trials (Cochrane RoB 2)

Study	D1	D2	D3	D4	D5	Overall
Sobolev et al. 2015 (22)	Low	Low	Low	Low	Low	Low

Note: D1, randomisation process; D2, deviations from intended interventions; D3, missing outcome data; D4, measurement of the outcome; D5, selection of the reported result. Green, low risk; amber, some concerns; red, high risk.

The single Group 3 study (29) was rated moderate, reflecting selection differences between arms and median-based reporting. No randomised comparison of suture against cartilage grafting using a standard symptom instrument was identified.

Discussion

Twelve studies (n = 471) of suture-based INV reconstruction in adults were synthesised and, for the first time, sorted into three mechanistically distinct classes. Symptomatic benefit was large in every class, and where objective measures were taken, the anatomic gains tracked it. That concordance argues for a mechanical rather than a placebo basis for the improvement. It does not establish that the suture did the work. Most series are single-arm, and several operated on the septum and turbinates at the same sitting, so the reported reductions belong to the operation as a whole. Direct comparison with grafting was available in only three studies: two found no difference between arms (23,29), and a three-arm randomised trial favoured a spreader graft over a percutaneous thread suspension (24). Two series merit direct comparison. Roughly 90% maintained relief at up to ten years followed a pure suture anchored to the piriform aperture (19), while the heaviest complication burden in the review followed a pure suture anchored to the infraorbital rim (22). Both are pure-suture constructs, and they differ chiefly in anchorage. Outcome may therefore track the anatomic target of the repair and the security of its bony fixation more closely than the presence or absence of a graft. The low certainty of the underlying studies bounds everything that follows.

Pure suture techniques

Pure suture techniques, which reposition the lateral nasal wall without adding structural material, accounted for the largest share of the evidence base (seven studies, n = 315). Their appeal rests on durability and low morbidity, with preservation of the native dorsal contour as a secondary gain. The piriform-anchored lateral suspension reported by Rizvi and Gauthier (19) remains the only INV repair of any kind with ten-year follow-up, maintaining symptomatic relief in 89.9% of patients; late failure from suture cut-through occurred in 10.1%, a rate that is plausibly intrinsic to any suture-dependent construct and that defines the principal long-term vulnerability of the class. Symptomatic efficacy within the group was substantial and instrument-independent: Shin et al. (20) documented a NOSE reduction from 65.4 to 20.5 (Hedges's g = 3.7) with concordant computed-tomographic widening of the valve angle (+43%) and cross-sectional area (+47 %), and Manickavasagam et al. (21) reported a visual-analog reduction from 7.7 to 2.9 with a 59% increase in peak inspiratory flow.

Two cautions temper this favourable profile, and both are instructive because they isolate the variables that drive outcome. The first is the anchoring site. The infraorbital-rim suspension described by André and Vuyk (22) produced only a modest gain on an unvalidated per-side scale (4.0 to 6.3 of 10) yet carried a 25% complication rate, including suborbital pain and swelling, re-exploration in three of twenty patients, and one permanent scar; the authors themselves advised against the technique as a first-line option. The contrast with the piriform-anchored construct (19) strongly implies that bony anchorage at the piriform aperture, rather than at the orbital rim, is responsible for the durability and safety that characterise the best pure-suture results. The second caution is the mechanical robustness of the construct. The minimally invasive barbed-thread suspension evaluated by Sobolev et al. (24) improved a modified obstruction score. Still, it was the least effective of the three arms. It produced the worst aesthetic outcomes, indicating that a percutaneous thread is a weaker construct than an open, securely anchored suspension and should not be taken as representative of the class. Finally, the flaring suture studied by Jalali (23) was deployed prophylactically during primary rhinoplasty in patients without preoperative obstruction; its rhinomanometric effect, although favourable in 63 percent, did not differ significantly from a spreader graft (p = 0.5), evidence that pertains to the prevention of iatrogenic narrowing rather than to the treatment of established collapse, and that should be interpreted in that narrower frame.

Hybrid suture-plus-cartilage-graft techniques

The four hybrid cartilage-graft studies (n = 148) delivered the largest anatomic gains and carried the strongest methodological quality of any group, at the cost of donor-site morbidity.

Ismail et al. (28), the largest single contributor of objective imaging data, combined a spreader graft with lateral flaring sutures and documented a NOSE reduction from 69.8 to 20.65 (within-arm Hedges's g ≈ 6.9) alongside widening of the valve angle from 74 to 80 per cent on both endoscopy and computed tomography, with 91% of patients sustaining relief at three years. Islam et al. (25), in a smaller series of 11 patients, reported marked symptomatic and acoustic-rhinometric improvement, with a 73 to 78 per cent increase in minimal cross-sectional area; the published report does not provide the NOSE means and standard deviations required to compute a verifiable standardised effect size, so no effect size is attributed to it here. Crucially, the addition of a cartilage graft did not compromise aesthetics when the construct was low-profile: Taştan et al. (26), in 19 patients, recorded significant functional improvement on the NOSE scale with unchanged Rhinoplasty Outcome Evaluation scores. The mechanistic rationale for this group is that a structural graft addresses fixed narrowing and intrinsic cartilage weakness that a suture alone cannot overcome: the graft resists collapse and provides a rigid scaffold, while the suture lateralises the lateral wall. The three uniformly low-risk-of-bias ratings in the review all fall within this group (25,26,28); it therefore offers not only the largest anatomic effect but also the most trustworthy evidence. Its inherent disadvantages (cartilage harvest from the septum, concha or rib, additional operative time, and dependence on graft availability) are most consequential precisely in the revision and cartilage-depleted patients for whom the third group was devised.

Hybrid suture-plus-autologous-tissue-flap techniques

The single soft-tissue-flap study (n=8) occupies a deliberately narrow niche. Akyurek et al. (29) suspended a de-epithelialised dermal-fat flap from the lateral orbital rim under local anaesthesia in revision patients who had undergone at least two prior nasal operations and in whom donor cartilage was depleted; the NOSE score fell from a median of 72.5 to a median of 27.5, approximately 62%. The decisive observation is that this result did not differ significantly from spreader grafting performed in the same study (postoperative p = 0.734), suggesting that an autologous sling can substitute for a cartilage graft when cartilage is unavailable. The technique's advantages (feasibility under local anaesthesia and avoidance of cartilage harvest) are offset by transient periorbital oedema in five of eight patients, one instance of six-month skin discolouration, and a very small, single-arm, short-follow-up evidence base. This group should therefore be regarded as a salvage option for a specific phenotype rather than as a general-purpose technique, and its promise awaits confirmation in larger series.

Which approach is best for internal nasal valve reconstruction?

The central question this review set out to inform does not have a single-technique answer, and the available comparative evidence (three small within-study comparisons) is insufficient to establish one. What follows is therefore offered as an explicitly hypothesis-generating, phenotype-based recommendation, derived by integrating the limited direct comparisons with mechanistic reasoning, durability and safety, rather than as a demonstrated hierarchy of techniques. The apparent tension in the comparative evidence is partly resolved upon examining the populations. The two studies that found suture and graft to be equivalent tested either prophylaxis in non-obstructed rhinoplasty patients (23) or salvage in cartilage-depleted revision patients (29), while the one study that found grafting superior tested a weak percutaneous thread against a rigid graft in a population that included fixed structural narrowing (24). The reconciling principle, that a robust, securely anchored suture suspension may match cartilage grafting when the dominant lesion is dynamic lateral-wall insufficiency or mild-to-moderate static narrowing with adequate native cartilage. In contrast, a structural graft is likely necessary when the dominant lesion is fixed narrowing or intrinsic cartilage weakness; this is biologically coherent but, on present data, remains a hypothesis.

On this basis, a phenotype-stratified algorithm is warranted by the evidence. For dynamic lateral-wall insufficiency and mild-to-moderate static narrowing in a patient with adequate cartilage, a piriform-anchored pure suture suspension is the best-supported first-line

choice: it matches grafting for symptomatic benefit, carries the lowest morbidity, preserves dorsal aesthetics, can be performed under local anaesthesia, and has the longest documented durability of any technique (19–21). When fixed structural narrowing or intrinsic cartilage weakness predominates, the repair should be escalated to a hybrid suture-plus-cartilage-graft, which delivers the largest anatomic correction and is supported by the strongest evidence, with the understanding that donor-site morbidity is the price of structural support (25,28). For revision patients with depleted cartilage or who are poor candidates for general anaesthesia, a hybrid suture-plus-autologous-flap is a reasonable salvage option (29). The practical rule is therefore to match the mechanical solution to the mechanical problem, anchor it securely at the piriform aperture, and add structural material only where the anatomy demands it.

The mechanical basis for suture-based correction follows directly from the geometry and physiology of the nasal valve. Because nasal airflow resistance varies inversely with approximately the fourth power of the radius at the constriction, small changes in valve dimensions produce disproportionately large changes in resistance. Computational fluid-dynamic studies have shown that changes in the INV angle on the order of five to ten degrees can reduce nasal resistance substantially, and that restoring the minimal cross-sectional area has a disproportionate effect on overall airflow efficiency (5,6). Suture techniques achieve this by direct lateral repositioning of the soft-tissue and cartilaginous lateral wall; structural grafts achieve it by rigid scaffolding. The concordance observed in this review between five-to-ten-degree angle gains and large symptomatic reductions across all three groups is consistent with this physiology and argues that these techniques converge by different mechanical means on the same final common pathway: restoration of valve cross-sectional area.

Comparison with previous reviews

Three earlier reviews cover neighbouring ground. The present findings agree with them about the state of the evidence and depart from them in what can be done with it.

Spielmann and colleagues, reviewing 43 studies of nasal valve surgery published up to 2008, found no randomised controlled trial, a single study at level IIIb evidence, and validated outcome instruments in only four reports (8). Goudakos and colleagues, searching MEDLINE, EMBASE, the Cochrane Library and CENTRAL with extensive hand searching, included 53 studies of which 50 were graded level IV, and identified exactly one randomised trial, comparing an autospreader flap against placebo with no significant difference (12). The present result is consistent with both. Of the twelve studies meeting the narrower suture-based criteria applied here, one was randomised (24), three offered any within-study comparator, and none compared a suture technique against cartilage grafting in a randomised design using a standard symptom instrument. Nearly two decades of further publication have not produced the comparative evidence that those reviews called for.

Two findings differ from the earlier reviews, concerning instrumentation and scope. Spielmann et al. found validated outcome measures in four of 43 studies, whereas eight of the twelve studies included here used a validated instrument and four used the standard 0 to 100 NOSE scale. That change makes the descriptive symptomatic synthesis reported here possible, and it follows the adoption of NOSE as a field standard after its validation in 2004 (1). Study design itself has not improved. Both earlier systematic reviews treated nasal valve surgery as a single field and attributed the proliferation of described techniques to uncertainty about which to choose (8,12).

Restricting the field to suture-based repair and stratifying it by mechanical class locates that uncertainty more precisely: the variation that appears to matter is anchorage site and construct robustness rather than the presence of a graft, a distinction visible only when the piriform-anchored and orbital-rim-anchored series are compared directly (19,22).

Sinkler and colleagues organised the operative options narratively into cartilage grafts, implants and suspension sutures, listing the piriform rim suspension, flaring suture, lateral pull-up, transconjunctival approach and Mitek bone anchor within the suspension family (13). Their grouping is anatomical and descriptive, and outcome data were neither extracted nor compared. The classification proposed here is mechanical and yields a prediction that a

prospective comparison could refute: that the anchorage site governs durability and morbidity. All three earlier reviews concluded that treatment must be directed at the specific lesion (12); the recommendation in section 4.4 restates that position in a form specific enough to test. The present findings diverge from Goudakos et al. on one point. Those authors concluded that the three-dimensional construction of the valve means many pathologies cannot be corrected by a single solution (12). As a statement about anatomy, this is not contradicted here. However, all three classes showed the same concordance between five- to ten-degree gains in valve angle and large symptomatic reductions, suggesting that mechanically distinct operations converge on a common endpoint of restored cross-sectional area. If so, the operative question becomes which mechanical route to that endpoint suits a given anatomy, rather than which technique is superior in general.

Clinical implications

The principal clinical implication of this review is that technique selection in INV reconstruction should be driven by the dominant anatomical lesion rather than by surgeon preference for suture or graft. Dynamic lateral-wall insufficiency, isolated valve collapse, and mild-to-moderate static narrowing are best addressed first by a piriform-anchored suture suspension; fixed structural narrowing, intrinsic cartilage weakness, severe high dorsal deviation, and congenital midvault collapse call for the structural support of a cartilage graft; and depleted-cartilage revision settings, or patients unsuitable for general anaesthesia, may be served by an autologous-flap suspension. Suture techniques are additionally attractive when graft material is depleted, when implants are unavailable or unaffordable, and when preservation of the native dorsal contour is a priority. In every case, secure piriform anchorage and a robust construct are preferable to orbital-rim anchorage or percutaneous threads.

Limitations

This review has several limitations. All included primary studies were observational, and no randomised comparison of suture-only against graft-based or implant-based INV repair has been published; therefore, the phenotype-stratified recommendation in section 4.4 rests on indirect reasoning rather than trial evidence. The studies were small, with a median of 27.5 patients (mean 39, range of 8 to 133). Heterogeneity in surgical technique limits direct comparison between them. Several series also performed concurrent septoplasty or turbinoplasty; in Shin et al. (20), every patient underwent both procedures, so the reported NOSE reductions reflect the combined effect of all procedures rather than the isolated contribution of the suture. Only two of twelve studies reported the dispersion required for a standardised effect size. This precluded meta-analytic pooling, left the prespecified subgroup analysis uninterpretable and the prespecified sensitivity analysis with an empty exclusion set, and made funnel-plot inspection and Egger regression unusable, so publication bias could not be assessed statistically.

The search covered theses and conference proceedings through ProQuest, registered trials through the Central Register of Controlled Trials, and the reference lists of all included articles and prior reviews, without language restrictions. No unpublished sources were found eligible; however, conference abstracts without peer review were excluded by design, and manufacturer and device registry reports were not searched. Bias in favour of positive published results therefore cannot be excluded and would, if present, inflate the symptomatic estimates reported here. Finally, the review was not prospectively registered, and the durability estimate rests on a single retrospective survey-based cohort (19); the ten-year figure should be read as a single low-certainty observation rather than an established property of the technique.

Future research

Three priorities follow from this synthesis. First, a phenotype-stratified randomised trial of piriform-anchored suture suspension versus spreader-graft repair in patients with isolated dynamic lateral-wall insufficiency, using a standard symptom instrument and objective valve metrics, would directly test whether the durability and morbidity advantages of suture techniques translate into clinical equivalence. Second, prospective registry data with a standardised core outcome set (NOSE, visual analog scale, Rhinoplasty Outcome Evaluation, acoustic rhinometry, and CT-based valve metrics) at fixed time points would permit

pooled analyses with reduced heterogeneity. Third, a larger, longer-follow-up evaluation of the autologous-flap approach and a head-to-head comparison of suture suspension against device-based techniques would clarify the remaining choices at the two ends of the complexity spectrum.

Conclusion

Suture-based internal nasal valve reconstruction produced large and consistent improvements in patient-reported obstruction across all three technique classes, with anatomic gains that tracked them, and low perioperative morbidity in every construct except orbital-rim suspension. No class was superior overall. What the evidence supports is a phenotype-based choice: a piriform-anchored pure suture suspension where the lesion is dynamic lateral-wall insufficiency or mild-to-moderate static narrowing with adequate cartilage; a suture-plus-cartilage-graft construct where fixed narrowing or intrinsic cartilage weakness predominates; and a suture-plus-autologous-flap as salvage in the cartilage-depleted revision patient. Durability and safety appeared to depend on the anchoring site and the anatomic substrate rather than on the presence of a graft. That proposition is the one most in need of testing. Nearly two decades after the first systematic review of this field reported that the literature described techniques more often than it measured patient benefit (8), the comparative evidence it called for is still lacking. A phenotype-stratified randomised comparison of suture suspension against graft-based repair, using a standard symptom instrument and objective valve metrics, remains the highest-priority study.

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