REVIEW ARTICLE

Orbital fat repositioning versus autologous fat grafting for lower eyelid and tear trough correction: a systematic review and meta-analysis

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ABSTRACT

Background: Lower eyelid rejuvenation involves correcting the protruding orbital fat and the tear trough that is adjacent. Fat repositioning and autologous fat grafting are two methods of contour rejuvenation, and comparative benefits are unclear. This systematic review and meta-analysis evaluated their efficacy and adverse effects after surgery in patients with lower eyelid bags or tear-trough deformity.

Methods: PubMed, Scopus, and Web of Science were searched up to October 2026. The records were screened, and data extracted independently by two authors. Randomized and non-randomized comparative studies were included. Effect estimates were pooled using random-effects models, 95% confidence intervals (CIs).

Results: Eight hundred twenty patients from five studies were included in the retrieved comparison groups. There was no significant difference between fat repositioning and grafting for pupil-to-tear-trough distance (standardized mean difference 0.47; 95% CI −0.01 to 0.94; I^2 = 71%) or Barton grade (mean difference 0.20; −0.45 to 0.85; I^2 = 94%). Nodules, induration, or bumps occurred less often after repositioning (risk ratio [RR] 0.27, 0.08 to 0.88), but significance varied between studies. Revision surgery did not differ (RR 0.88, 0.34 to 2.27).

Conclusion: There is no consistent aesthetic advantage for either technique as shown by available comparative evidence. Repositioning may lead to a decrease in nodules or induration, and grafting results seem to be technique and donor dependent. The small number of studies, observational designs, heterogeneous measurements, and mixed analysis units limit the ability to make firm treatment recommendations.

Keywords: Autologous fat grafting, blepharoplasty, fat repositioning, orbital fat, tear trough.

Introduction

Lower eyelid bags and tear-trough depression often occur together, resulting in a break between the eyelid and cheek. They are a result of multiple factors such as prominence of the orbital fat, loss of supporting tissue, and volume loss in the region [1,2]. Anatomical studies have shown the presence of a tear-trough ligament that is connected laterally to the orbicularis retaining

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ligament, which accounts for the fact that a seemingly simple hollow may need more than superficial filling [3]. Treatment is thus based on the extent of the deformity and the presence of excess skin and the relationship between protruding fat and nearby volume loss [4]. Aesthetic correction must also preserve lower eyelid position and function.

The modern approach to blepharoplasty is more focused on preserving volume and selectively augmenting the eyelids than indiscriminate tissue removal [5,6]. Orbital fat repositioning mobilizes pedicled fat across the orbital rim to fill the depression while maintaining continuity with its original compartment [7]. Fat grafting involves transferring free fat to the area of deficiency and allows for augmentation beyond the reach and/or volume of a pedicle. These can be used with either transcutaneous or transconjunctival access, depending on the tissues to be corrected [8]. The surveys of specialist practice show substantial differences in the operative methods and additional procedures used, reflecting the lack of a standardized treatment pathway [9].

This technical diversity complicates comparison. In a review on the tear-trough surgery, several dissection planes, fixation techniques, and grafting options were discussed, but none were consistently better [10]. A meta-analysis of periorbital autologous fat grafting showed high satisfaction, with mostly uncontrolled evidence, which precluded the ability to conclude that grafting was superior to repositioning [11]. A later synthesis looked at complications for both strategies, but pooled complication rates do not convey the same information as direct comparative effects [12]. A more recent comparison of surgical access also revealed inconsistent reporting of outcomes and complications [13]. These differences are important because free grafts can be donor-site fat injected, segmental grafts or minced orbital fat, each having different handling and placement properties.

A targeted comparison assessment is thus required to distinguish the treatment comparison from the differences due to graft source, study design, and outcome measurement. Photographic changes, clinical grading, contour irregularities, and additional surgery are all measures of treatment success, and none of these alone defines the preferred surgery. This systematic review and meta-analysis was performed to compare the aesthetic results and complications following orbital fat repositioning and autologous fat grafting for lower eyelid and tear-trough correction and to assess the quality and applicability of the comparative evidence.

Methods

Protocol and registration

The review was registered in PROSPERO under registration number: CRD420261560349. The study was conducted according to Cochrane Handbook of Systematic Reviews of Intervention [14], and reporting was structured according to the PRISMA 2020 statement [15].

Eligibility criteria

We included studies according to a predefined PICOS format. Population: Patients undergoing surgical treatment of lower eyelid bags, tear-trough deformity, or orbital rim hollowing were eligible. Intervention: The intervention was pedicled orbital fat repositioning or transposition. Comparator: The comparator was autologous free fat grafting using resected orbital fat or fat harvested from an extra-orbital donor site. Outcomes: Eligible comparisons reported aesthetic correction or postoperative complications relevant to the lower eyelid and tear trough. Study design: Randomized trials and non-randomized comparative clinical studies were included. Studies of other populations or upper eyelids, other interventions or comparators, and reviews were excluded. In addition, non-comparative reports that did not address the comparative review question were also excluded.

Information sources and search strategy

PubMed, Scopus, and Web of Science were searched through October 2026. The strategies combined terms for blepharoplasty, the lower eyelid, tear trough, nasojugal or infraorbital regions, and fat repositioning, transposition, transfer, injection, or grafting. Database-specific syntax and record counts are reproduced in Supplementary Table S1. No additional date or language restrictions were applied.

Study selection and data extraction

Two authors independently screened records using Rayyan platform [16] and evaluated potentially eligible full texts. Disagreements were resolved by discussion, with a third author consulted when necessary. Two authors independently extracted data using the same approach to disagreement resolution. Extracted items included study design, setting, population, sample size, age, sex, baseline tear-trough grade, operative approach, graft source and delivery, fixation technique, follow-up, aesthetic outcomes, complications, and revision surgery. Fat repositioning was consistently designated the experimental arm and fat grafting the comparator, irrespective of the original study labels. Photographic outcomes used the available assessment subset rather than the whole enrolled cohort where appropriate.

Risk of bias

The randomized trial was assessed using RoB 2 [17], addressing randomization, deviations from intended interventions, missing outcome data, outcome measurement, and selection of reported results. Non-randomized studies were assessed using ROBINS-I [18], which additionally considers confounding, participant selection, and intervention classification.

Outcomes and statistical analysis

The primary outcomes were pupil-to-tear-trough distance, Barton tear-trough grade, and fat nodules, palpable induration, or bumps. Secondary outcomes were revision surgery, hematoma, pain, residual or recurrent

fat bulging, and pupil-to-lower-eyelid-margin distance. Analyses were performed in R version 4.5.2 using the meta package [19]. Dichotomous outcomes were pooled as risk ratios (RRs) and continuous outcomes as mean differences (MDs) with 95% confidence intervals (CIs). Standardized mean differences (SMDs; Hedges' g) were used for the photographic distance outcomes because one study used a non-comparable measurement scale. Continuous effects were expressed as repositioning minus grafting; positive effects for the harmonized distance and Barton outcomes indicated less improvement after repositioning. For adverse events, an RR below 1 favored repositioning.

Random-effects models were used throughout, with restricted maximum-likelihood estimation of between-study variance (τ^2). Common-effect estimates used inverse-variance methods for continuous outcomes and Mantel–Haenszel methods for dichotomous outcomes. Prediction intervals were reported where available. A continuity correction of 0.5 was applied to studies with a zero event cell; studies with no events in either arm were excluded from that outcome's pooled estimate. Heterogeneity was assessed using Cochran's Q, I^2, and τ^2; Q-test $p < 0.10$ indicated heterogeneity, while I^2 values around 25%, 50%, and 75% were interpreted as low, moderate, and high [20].

Sensitivity analyses included leave-one-out pooling, Hartung–Knapp CIs, Peto ORs for rare events, exclusion of non-comparable measurement scales, and a patient-denominator sensitivity analysis for the eye-level Barton data. The supplied Barton analyses combined change scores from Chiu et al. with postoperative grades from Li et al. and Liu et al.; the latter were converted from medians and interquartile ranges in the supplied analysis. The conversion algorithm and within-patient correlation adjustment were not documented. Exploratory subgroup analyses compared extra-orbital versus resected orbital graft sources and randomized versus non-randomized designs, using tests for subgroup differences. Contour-enhanced funnel plots were examined descriptively [21]. Formal small-study-effect testing and trim-and-fill were not undertaken because fewer than ten studies contributed to each outcome. Tests were two-sided, with $p < 0.05$ considered statistically significant unless otherwise specified.

Results

Study selection

The searches identified 614 records: 250 from PubMed, 172 from Scopus, and 192 from Web of Science. After removal of 374 duplicates, 240 records were screened and 227 were excluded. All 13 reports sought for retrieval were obtained and assessed. Eight were excluded because of another population or upper-eyelid focus ($n = 5$), other interventions or comparators ($n = 2$), or review design ($n = 1$). Five studies were included in the qualitative and quantitative synthesis (Figure 1) [22–26].

Study characteristics

The five studies were published between 2017 and 2025 and contributed 820 patients across the extracted comparison groups: 419 treated with repositioning and 401 with grafting (Table 1). One was randomized and four were non-randomized comparative studies. Three were conducted in China, one in Sweden, and one in Iran. The Chinese cohorts were generally younger, with mean ages around 30–34 years, compared with approximately 48 years in the Swedish and Iranian cohorts. Women predominated, and mean follow-up ranged from 7.9 to 13.3 months.

Chiu et al. reported 202 eyes from 101 patients. Hedén et al. provided 329 patients in its comparison tables, although its narrative described 339 procedures and ten mixed-treatment cases; the extracted group totals were retained without adding these cases. Its photographic outcomes included 106 repositioning and 110 grafting patients after exclusions for unavailable or unsuitable photographs. The other studies contributed 142, 40, and 208 patients, respectively. Author groups and reported institutions did not indicate an obvious duplicate cohort.

Grafting comprised thigh-fat lipoinjection in Chiu et al., segmental grafts from the groin or abdomen in Hedén et al., and resected minced orbital fat in Karimi et al., Li et al., and Liu et al. Minced grafts were placed under direct vision or injected. Repositioning used pedicled orbital fat with internal or percutaneous fixation. Procedures were predominantly transconjunctival except in Hedén et al., where most used a subciliary approach. The study-level techniques and baseline characteristics are detailed in Table 1.

Risk of bias

The supplied RoB 2 assessment judged Li et al. to have some concerns overall, arising from randomization, outcome measurement, and selection of reported results; deviations from intended intervention and missing outcome data were judged low risk. All four non-randomized studies were rated moderate overall under ROBINS-I. Confounding was rated moderate in each study. Participant selection and selective reporting were rated moderate in Chiu et al., Hedén et al., and Karimi et al.; Hedén et al. also had moderate concern for deviations from intended interventions. Liu et al. had moderate concern for missing data and outcome measurement. Other domains were rated low risk (Figure 2).

Pupil-to-tear-trough distance

Three studies (464 patients) reported the percentage change from baseline in the vertical distance between the pupil center and the lowest point of the tear trough at last follow-up (Hedén 2021; Li 2025; Liu 2025). Because Li 2025 reported this measure on a scale not directly comparable with the other studies, results were pooled as a SMD. The reduction in distance tended to be smaller after FR than after FG, but the difference did not reach statistical significance (SMD 0.47, 95% CI −0.01 to 0.94; $p = 0.053$). Heterogeneity was substantial ($I^2 = 71\%$, $\tau^2 = 0.132$; 95% prediction interval −1.41 to 2.34) (Figure 3).

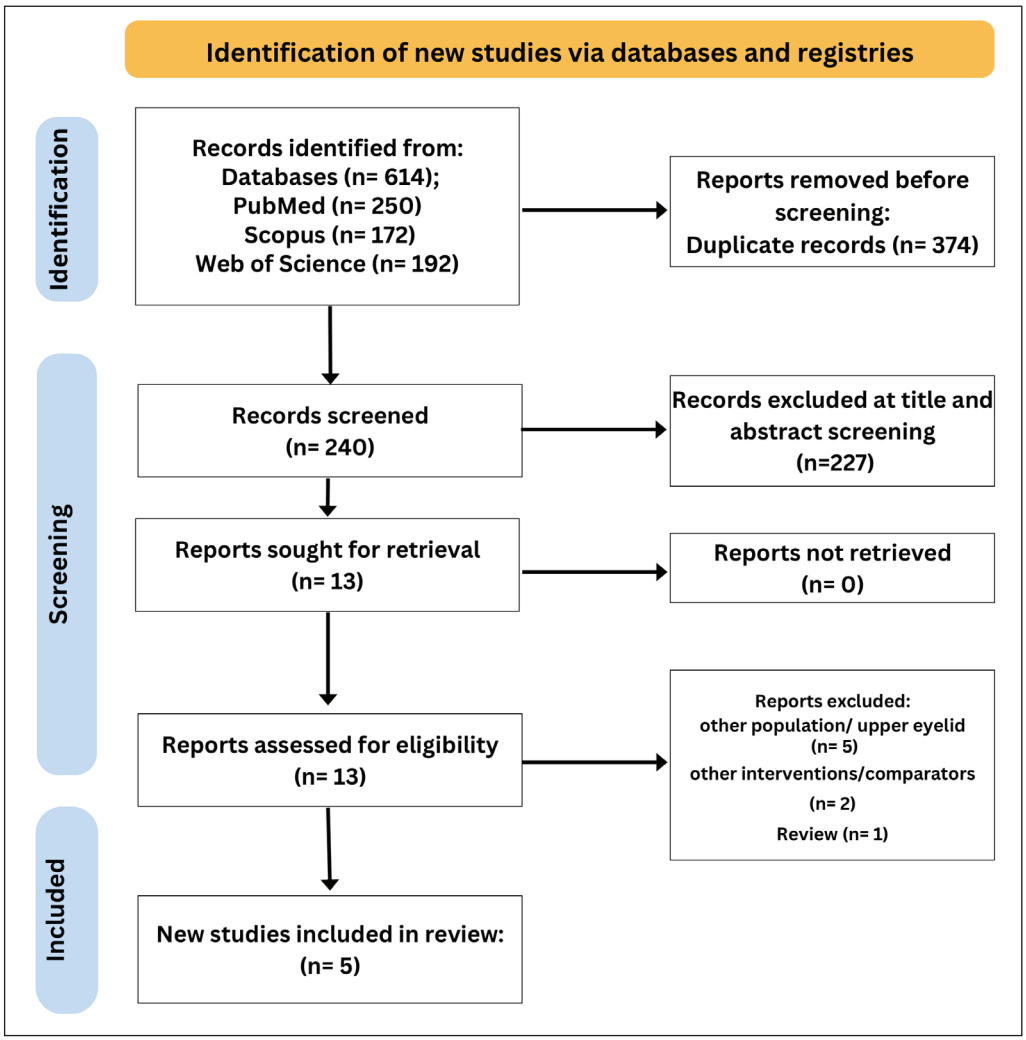


Figure 1. *PRISMA 2020 flow diagram of study identification, screening and inclusion.*

The common-effect estimate was statistically significant (SMD 0.33, 95% CI 0.15 to 0.52).

The leave-one-out analysis identified Li 2025 as the main source of heterogeneity (Supplementary Figure S1). Without it, FG produced a significantly greater reduction in distance than FR (SMD 0.27, 95% CI 0.05 to 0.49; $p = 0.017$; $I^2 = 25\%$). In the two studies that used the same scale (Hedén 2021; Liu 2025), this corresponded to a mean difference of 2.32 percentage points (95% CI 0.80 to 3.84; $p = 0.003$; $I^2 = 0\%$). Omitting Hedén 2021 (SMD 0.68, 95% CI −0.02 to 1.38) or Liu 2025 (SMD 0.58, 95% CI −0.35 to 1.51) did not change the direction of effect. With the Hartung–Knapp adjustment, the CI widened considerably (−0.66 to 1.59; $p = 0.22$) (Table 2).

By graft source, the effect was close to zero when extra-orbital donor fat was grafted (one study; SMD 0.16, 95% CI −0.11 to 0.43) and larger when minced orbital fat was grafted (two studies; SMD 0.68, 95% CI −0.02 to 1.38). The difference between subgroups was not significant ($p = 0.17$) (Supplementary Figure S2). By study design, the randomized trial showed a larger effect (SMD 1.11, 95% CI 0.44 to 1.78) than the non-randomized studies (SMD 0.27, 95% CI 0.05 to 0.49; test for subgroup differences $p = 0.019$) (Supplementary Figure S3). Because the randomized trial is also the study with the non-comparable scale, this difference cannot be attributed to study design alone.

Barton tear-trough grade

Three studies (450 analysis units, combining eyes from Chiu 2017 with patients from Li 2025 and Liu 2025) reported the Barton tear-trough grade (Chiu 2017; Li 2025; Liu 2025). Chiu 2017 reported change from baseline, whereas Li 2025 and Liu 2025 reported postoperative grades with baseline grades balanced between groups; these were pooled as MD. Overall, the Barton grade did not differ between FR and FG (MD 0.20, 95% CI −0.45 to 0.85; $p = 0.54$). However, heterogeneity was considerable ($I^2 = 94\%$, $\tau^2 = 0.303$; 95% prediction interval −2.56 to 2.97) and the individual studies pointed in opposite directions (Figure 4).

Effects differed across graft-source subgroups (Figure 5). Compared with lipoinjection of extra-orbital fat, FR produced a greater improvement in Barton grade (Chiu 2017; MD −0.40, 95% CI −0.60 to −0.20). Compared with grafting of minced orbital fat, FR produced a smaller improvement (Li 2025; Liu 2025; MD 0.48, 95% CI 0.09 to 0.87; $I^2 = 57\%$). The difference between subgroups was

Table 1. *Characteristics of the included studies.*

Study (country)	Design	Patients, n FR / FG	Age, y FR / FG	Female, % FR / FG	Repositioning technique	Grafting technique (fat source; delivery)	Follow-up, mo FR / FG	Outcomes pooled
Chiu 2017 (China)	Retrospective comparative	51 / 50 (102 / 100 eyes)	32.5 (20–43)[a]	93[a]	Transconjunctival; pedicled fat flaps with septal reset, sutured to periosteum 3–5 mm below the rim	Extra-orbital: inner-thigh fat, lipoinjection (18-G needle) into the orbicularis along the rim	11.5 (6–20)[a]	Barton grade; nodules; revision
Hedén 2021 (Sweden)	Retrospective comparative	169 / 160	48.4 / 47.6	87 / 85	Mainly subciliary (transconjunctival 5% FR; 8% FG); medial fat pad transposed and fixed with percutaneous sutures	Extra-orbital: segmental en-bloc graft from groin/abdomen (≤0.5 × 4 cm) placed onlay at the tear trough, percutaneous suture fixation	12.4 / 13.3 (5–120)	Tear-trough distance; eyelid-margin distance; hematoma; revision
Karimi 2024 (Iran)	Retrospective comparative (quasi-experimental)	73 / 69	48.8 / 48.0	93 / 96	Transconjunctival; preperiosteal pedicled fat flaps fixed with transcutaneous mattress sutures	Orbital: resected lower-lid fat minced (3–5 mm), placed with forceps into a preperiosteal pocket without fixation	8.6 / 7.9 (6–36)	Nodules; revision; pain; residual bulging
Li 2025 (China)	Randomized controlled trial	20 / 20	33.8 / 32.1	90 / 85	Transconjunctival; released fat flap with internal or external suture fixation	Orbital: resected fat minced and injected along the periosteum (20-G needle); retaining ligament not released	12 (scheduled 3, 6, 12)	Tear-trough distance; Barton grade; nodules; hematoma; pain; residual bulging; eyelid-margin distance
Liu 2025 (China)	Retrospective comparative	106 / 102	31.1 / 29.8	71 / 75	Transconjunctival; two fat flaps per side with percutaneous external fixation	Orbital: resected fat minced and injected along the periosteum (23-G blunt cannula)	11.6 / 11.2 (3–24)	Tear-trough distance; Barton grade; nodules; hematoma; pain; residual bulging; eyelid-margin distance

Values are means (range) where available; ages in Hedén, Karimi, Li and Liu are group means. [a] Whole Chiu cohort (101 patients). FR, fat repositioning; FG, fat grafting; G, gauge.

significant ($\chi^2 = 15.35$, df = 1, $p < 0.001$). Study design did not explain the heterogeneity (randomized trial: MD 0.75, 95% CI 0.26 to 1.25; non-randomized studies: MD −0.03, 95% CI −0.75 to 0.68, $I^2 = 96\%$; test for subgroup differences $p = 0.078$) (Supplementary Figure S4).

In the leave-one-out analysis, omitting Chiu 2017 shifted the pooled estimate in favor of FG (MD 0.48, 95% CI 0.09 to 0.87; $p = 0.016$; $I^2 = 57\%$), whereas omitting Li 2025 (MD −0.03, 95% CI −0.75 to 0.68) or Liu 2025 (MD 0.15, 95% CI −0.97 to 1.28) did not (Supplementary Figure S5). The overall result did not change when the originally extracted standard deviations were used (MD 0.20, 95% CI −0.45 to 0.85) or when Chiu 2017 was analyzed per patient instead of per eye (MD 0.21, 95% CI −0.44 to 0.85) (Table 2).

Fat nodules, palpable induration and bumps

Four studies (592 analysis units, combining eyes and patients) reported fat nodules, palpable induration, or bumps. These occurred in 2 of 301 FR cases (0.7%) and 14 of 291 FG cases (4.8%). FR was associated with a significantly lower risk (RR 0.27, 95% CI 0.08 to 0.88; $p = 0.030$; $I^2 = 0\%$), and the common-effect Mantel–Haenszel estimate was similar (RR 0.22, 95% CI 0.07 to 0.69) (Figure 6). In Chiu 2017, all seven indurations after lipoinjection resolved with intralesional steroid injection, whereas the single nodule in the grafting arm of Li 2025 required two further operations.

The result depended partly on individual studies (Supplementary Figure S6). It was no longer significant after omitting Chiu 2017 (RR 0.36, 95% CI 0.10 to 1.33; $p = 0.13$) or Karimi 2024 (RR 0.18, 95% CI 0.03 to 1.03; $p = 0.054$), but remained significant after omitting Li 2025 or Liu 2025 (both RR 0.26, 95% CI 0.07 to 0.93). It was robust to the Hartung–Knapp adjustment (RR 0.27, 95% CI 0.08 to 0.88; $p = 0.039$) and to the Peto odds ratio, used as a rare-event sensitivity analysis (OR 0.21, 95% CI 0.08 to 0.55; $p = 0.002$) (Table 2). Subgroup differences were not significant by graft source (extra-orbital fat: RR 0.07, 95% CI 0.00 to 1.13; minced orbital fat: RR 0.36, 95% CI 0.10 to 1.33; $p = 0.29$) (Supplementary Figure S7) or by study design ($p = 0.88$) (Supplementary Figure S8).

Revision surgery

Three studies (673 analysis units, combining eyes and patients) reported revision surgery, which was needed in 23 of 344 FR cases (6.7%) and 27 of 329 FG cases (8.2%). The risk of revision did not differ between techniques (RR 0.88, 95% CI 0.34 to 2.27; $p = 0.80$; $I^2 = 63\%$) (Supplementary Figure S9). Omitting Chiu 2017 reduced heterogeneity ($I^2 = 13\%$) without changing the conclusion (RR 1.34, 95% CI 0.61 to 2.93) (Supplementary Figure S10). By graft source, revision tended to be less frequent after FR than after extra-orbital grafting (RR 0.60, 95% CI 0.25 to 1.43) and more frequent than after minced orbital fat grafting (RR 2.13, 95% CI 0.69 to 6.59), but

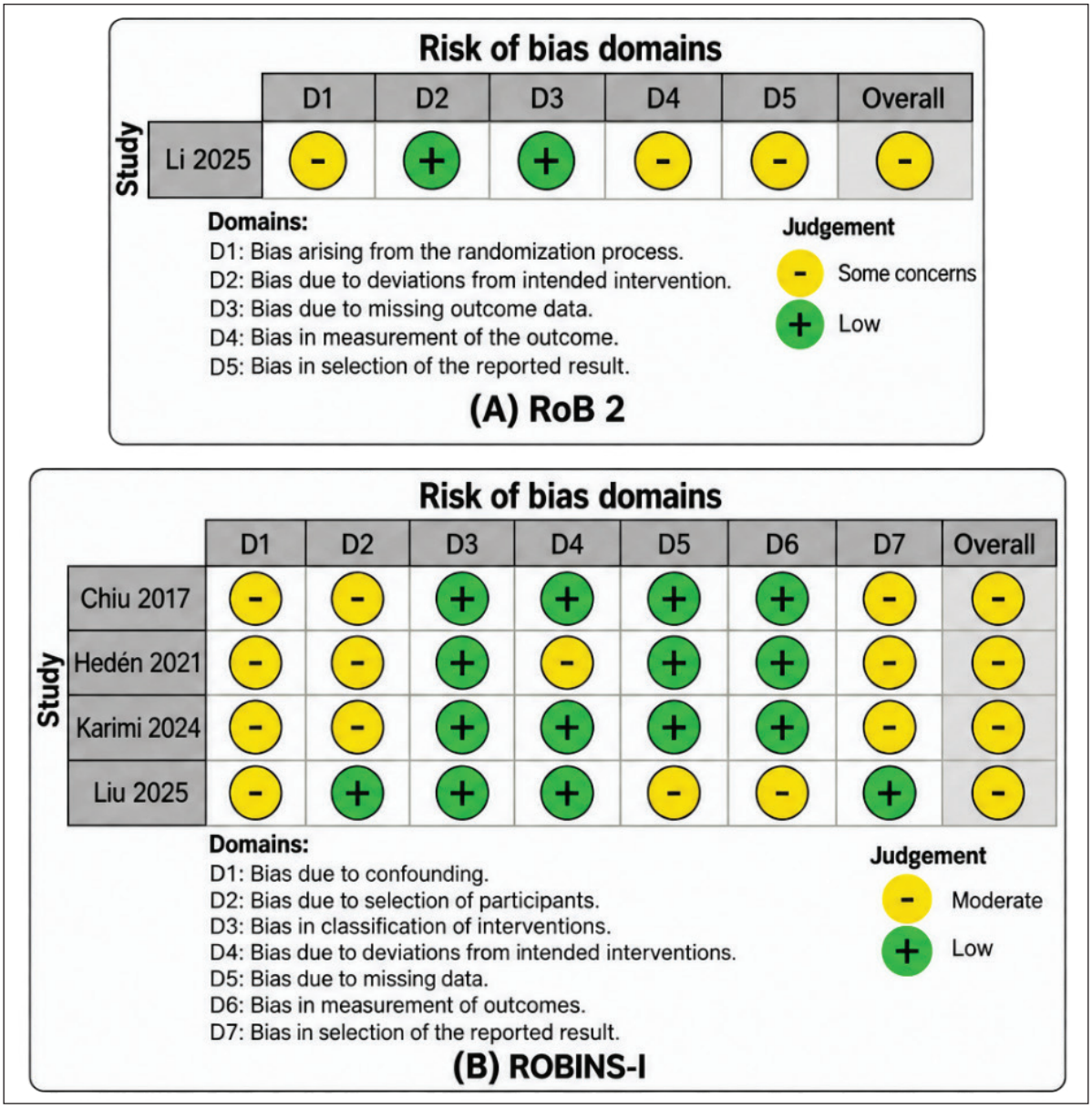


Figure 2. *Supplied risk-of-bias assessment. (A) RoB 2 for the randomized trial. (B) ROBINS-I for non-randomized comparative studies.*

the subgroup difference was not significant (p = 0.082) (Supplementary Figure S11). Indications for revision differed between studies: unsatisfactory correction or contour irregularity in Chiu 2017, fat or skin excision in Hedén 2021, and residual eyelid puffiness in Karimi 2024.

Other postoperative complications

The risk of hematoma did not differ between techniques (three studies, 577 participants; 8 of 295 *vs.* 6 of 282; RR 1.30, 95% CI 0.46 to 3.65; p = 0.62; I^2 = 0%) (Supplementary Figure S12). Neither did the risk of postoperative pain (two estimable studies, 248 participants; RR 1.64, 95% CI 0.63 to 4.24; p = 0.31; I^2 = 0%) (Supplementary Figure S13); Karimi 2024 reported no pain in either group and did not contribute to this estimate. Residual or recurrent fat bulging occurred in 17 of 199 FR patients (8.5%) and 7 of 191 FG patients (3.7%), a difference of borderline significance (RR 2.31, 95% CI 0.98 to 5.42; p = 0.055; I^2 = 0%) (Supplementary Figure S14).

Pupil-to-lower-eyelid-margin distance

Lower eyelid margin position changed little and similarly with both techniques (three studies, 464 patients; SMD 0.13, 95% CI −0.05 to 0.32; p = 0.15; I^2 = 0%). In the two studies that used the same scale, the mean difference was 0.19 percentage points (95% CI −0.06 to 0.45) (Supplementary Figure S15).

Publication bias

Fewer than ten studies contributed to each outcome, so formal tests for small-study effects (Egger's regression test and trim-and-fill) were not performed. Contour-enhanced funnel plots for the three primary outcomes are provided as exploratory (Supplementary Figures S16–

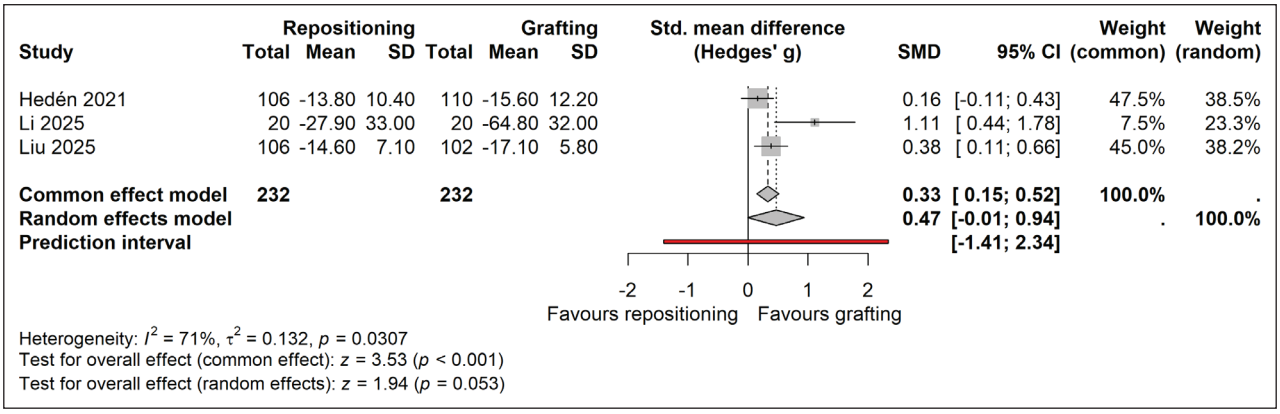


Figure 3. *Forest plot of the pupil-to-tear-trough distance (primary outcome). Percentage change from baseline in the vertical distance between the pupil centre and the lowest point of the tear trough at last follow-up. Squares represent individual study estimates (size proportional to weight) with horizontal lines showing 95% CIs. Diamonds show the pooled common-effect (inverse-variance) and random-effects (restricted maximum-likelihood estimator of τ^2) estimates; the red bar is the 95% prediction interval. SMD, standardized mean difference; FR, orbital fat repositioning; FG, fat grafting; CI, confidence interval; SD, standard deviation.*

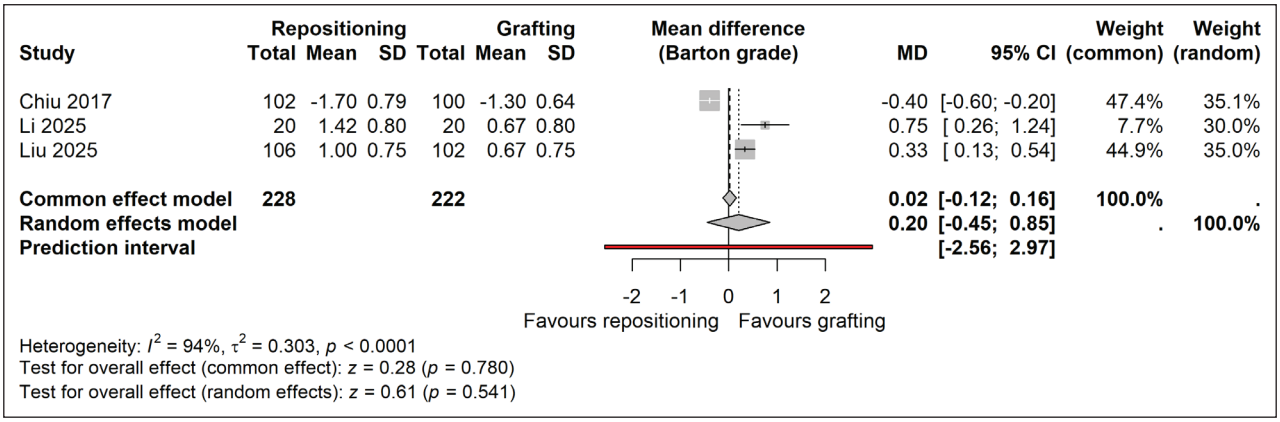


Figure 4. *Forest plot of the Barton tear-trough grade (primary outcome). Mean differences calculated as FR minus FG; negative values indicate a lower (better) grade or a greater improvement after repositioning. Squares represent individual study estimates (size proportional to weight) with horizontal lines showing 95% CIs. Diamonds show the pooled common-effect (inverse-variance) and random-effects (restricted maximum-likelihood estimator of τ^2) estimates; the red bar is the 95% prediction interval. MD, mean difference; FR, orbital fat repositioning; FG, fat grafting; CI, confidence interval; SD, standard deviation.*

S18); with three or four studies per outcome, they cannot reliably show asymmetry.

Discussion

This synthesis indicates that a single ranking of effectiveness for orbital fat repositioning versus free fat grafting cannot be made. The main aesthetic comparisons did not consistently favor one approach, whereas the pooled nodule outcome favored repositioning but was sensitive to the omission of individual studies. These results indicate an uncertain equivalence between contour correction and local irregularity, but not between operations. A non-significant difference is particularly hard to interpret when the CI still includes potentially important benefit in either direction. This is further complicated by the fact that several grafting procedures are grouped together. The differences between donor-site lipoinjection, onlay segmental graft and minced orbital grafts lie in their composition, placement, and dissection associated with their use.

There are some useful previous reviews that address more general questions. Including 39 studies and 4,046 eyelid or periorbital fat grafting procedures, Yang et al. found a pooled satisfaction rate of 90.9% and an overall complication rate of 7.9% [11]. Those findings suggest that grafting is clinically feasible, but are not sufficient to conclude that it is superior to repositioning since the majority of the studies were case series. In the same manner, a collection of 33 studies with 4,671 patients included complications of grafting/repositioning such as contour irregularity and reoperation [12]. The overall complication estimates should not be compared with our outcome-specific RRs. Differences in eligibility, event definitions, treatment combinations, and follow-up can change absolute rates substantially. Our contribution is the direct comparison, although the small underlying

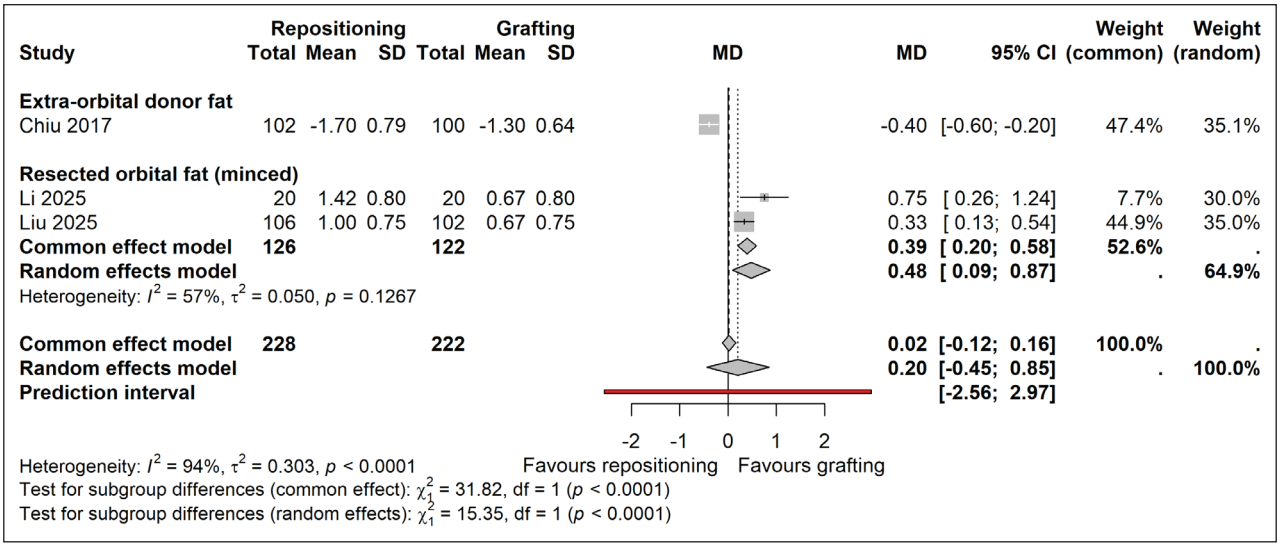


Figure 5. *Subgroup analysis of the Barton tear-trough grade by graft source. Studies were grouped by graft source: extra-orbital donor fat (thigh lipoinjection; Chiu 2017) or resected orbital fat that was minced and injected (Li 2025; Liu 2025). Mean differences calculated as FR minus FG; negative values favour repositioning.*
Pooled estimates are shown within each subgroup and overall; the test for subgroup differences is reported under both the common-effect and random-effects models. Subgroups contain one to three studies, so this analysis is exploratory. MD, mean difference; FR, orbital fat repositioning; FG, fat grafting; CI, confidence interval; SD, standard deviation.

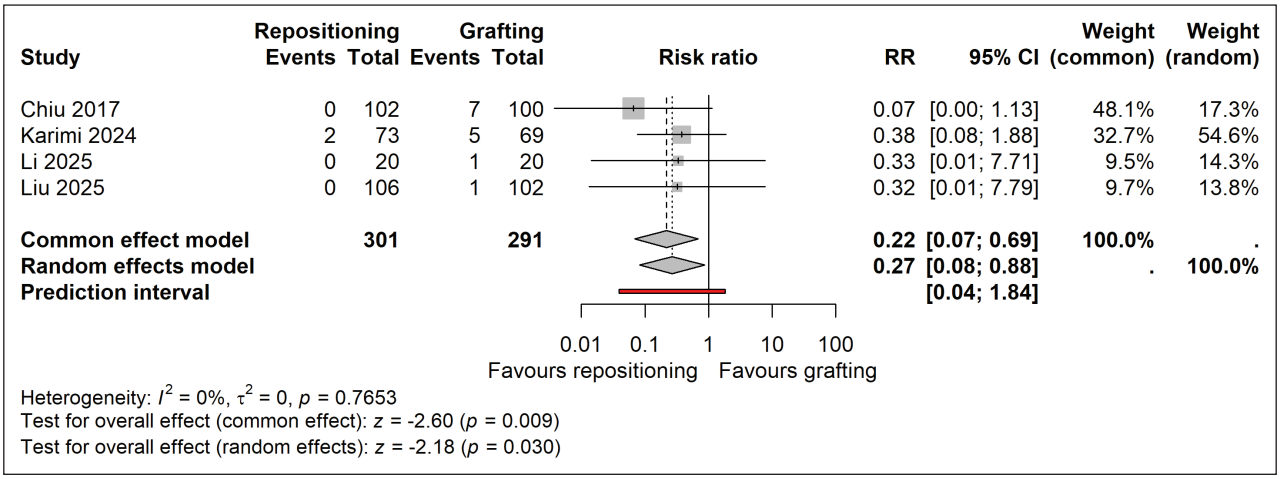


Figure 6. *Forest plot of fat nodules, palpable induration or bumps (primary safety outcome). Risk ratios for FR versus FG; values below 1 indicate fewer events after repositioning.*
Squares represent individual studyRRs (size proportional to weight) with horizontal lines showing 95% CIs. Diamonds show the pooled common-effect (Mantel–Haenszel) and random-effects (inverse-variance, restricted maximum-likelihood estimator of τ^2) estimates; the red bar is the 95% prediction interval. A continuity correction of 0.5 was applied to studies with a zero cell. RR, risk ratio; FR, orbital fat repositioning; FG, fat grafting; CI, confidence interval; SD, standard deviation.

evidence base still prevents confident attribution of differences to the operative strategy alone.

The apparent importance of graft source is plausible but has not been proven. There was one lipoinjection study and two studies of minced orbital fat, and the Barton subgroup contrast reflected this. The result for the subgroup should not be interpreted as evidence that the effect of changing the donor site is necessarily different. However, the procedures are discussed separately in earlier technical reports, for reasons. Miranda and Codner reported direct lower blepharoplasty micro free orbital fat grafts [27]. A larger retrospective series assessed transconjunctival fat removal and grafting of the excised fat [28]. These techniques enable the placement of excised tissue in a depression, as opposed to only correcting what can be reached by a vascularized pedicle. Their uncontrolled results do not provide any causal explanation of the pooled subgroup difference, but rather further comparison.

Other sources of variation are the release of retaining structures and the amount of augmentation. Wong et al. reported on an expanded transconjunctival technique that involved both ligament release and orbital fat redistribution and grafting of excised orbital fat [29].

Table 2. *Pooled outcomes and sensitivity analyses for fat repositioning versus fat grafting.*

Outcome	Studies (analysis units)	Pooled effect, random effects (95% CI)	P	I^2	Sensitivity analyses (95% CI)
Primary outcomes					
Pupil-to-tear-trough distance, % change	3 (464)	SMD 0.47 (−0.01 to 0.94)	0.053	71%	Excluding Li 2025: SMD 0.27 (0.05 to 0.49); MD 2.32 % points (0.80 to 3.84) Hartung–Knapp: SMD 0.47 (−0.66 to 1.59)
Barton tear-trough grade	3 (450)[a]	MD 0.20 (−0.45 to 0.85)	0.54	94%	Orbital-fat grafting studies only: MD 0.48 (0.09 to 0.87) Chiu 2017 per patient: MD 0.21 (−0.44 to 0.85) Hartung–Knapp: MD 0.20 (−1.23 to 1.63)
Fat nodules / induration / bumps	4 (592)[a]	RR 0.27 (0.08 to 0.88)	0.030	0%	Peto OR 0.21 (0.08 to 0.55) Excluding Chiu 2017: RR 0.36 (0.10 to 1.33) Hartung–Knapp: RR 0.27 (0.08 to 0.88)
Secondary outcomes					
Revision surgery	3 (673)[a]	RR 0.88 (0.34 to 2.27)	0.80	63%	Excluding Chiu 2017: RR 1.34 (0.61 to 2.93) Hartung–Knapp: RR 0.88 (0.11 to 7.08)
Hematoma	3 (577)	RR 1.30 (0.46 to 3.65)	0.62	0%	—
Pain	2 (248)[b]	RR 1.64 (0.63 to 4.24)	0.31	0%	—
Residual / recurrent fat bulging	3 (390)	RR 2.31 (0.98 to 5.42)	0.055	0%	—
Pupil-to-lower-eyelid-margin distance, % change	3 (464)	SMD 0.13 (−0.05 to 0.32)	0.15	0%	Excluding Li 2025: MD 0.19 % points (−0.06 to 0.45)

Continuous effects are FR minus FG; positive values indicate less improvement after FR for the harmonized distance and Barton outcomes. RR <1 indicates fewer events after FR. Random-effects models used restricted maximum likelihood and Wald-type 95% CIs unless stated. [a] Totals combine eyes from Chiu 2017 with patients from other studies and are not counts of unique patients. [b] Karimi 2024 had no pain events in either arm and was not estimable. The supplied patient-denominator Barton sensitivity does not document a paired-eye correlation adjustment. CI, confidence interval; MD, mean difference; OR, odds ratio; RR, risk ratio; SD, standard deviation; SMD, standardized mean difference.

These procedures are examples of how repositioning and grafting do not always have to be distinct treatment categories. In clinical practice, a patient may need to have a prominence reduced and also to have something added to it. In a small study of three-dimensional combined fat-pad transposition and grafting, a significant postoperative volume increase was measured [30]. That study cannot tell the independent contribution of either component, but it does demonstrate why a one-dimensional photographic distance might not fully reflect the operative goal. When comparing future results, it is important to record the degree of ligament release, the recipient plane, the amount of fat injected and any other additional procedures performed and to credit the results to the general term fat management.

The durability and smoothness of repositioned fat may also be affected by fixation. Both needle-assisted internal fixation and guided internal anchoring techniques have been published, both of which aim to facilitate the placement and to secure the pedicle [31,32]. A more recent transcutaneous series evaluated outcomes with the use of percutaneous external fixation and Barton grading and patient-reported measures [33]. These studies are a testament to the fact that there is still technical variation and not superiority of a particular method of fixation. In the comparisons included, fixation and surgical access were not controlled between studies. Residual bulging may be due to limited pedicle reach, incomplete redistribution, postoperative displacement or original anatomical pattern, but the present data do not differentiate these possibilities. This borderline pooled result for residual or recurrent bulging should therefore be a call to action to better characterize failure and not a call to action to categorically prefer grafting.

The decrease in nodules or induration with repositioning is a factor that should be considered as even slight contour irregularities could be noticeable under the thin lower eyelid skin. Free graft placement adds variation in particle size, distribution, and tissue handling. A study of non-vascularized fat grafts in an experimental model showed that the peripheral adipocytes survived, with areas of regeneration and necrosis, thus offering a biological explanation for the mixed behavior of fat grafts [34]. This is not evidence that necrosis was the cause of the events recorded in these clinical studies, but mechanistic support. Transient palpable induration was also combined with persistent nodules that needed additional procedures, which constituted the composite outcome. These events should be broken down into visibility, persistence, patient concern, and treatment required in a future safety comparison. The pooled association should be explained to patients as a potential variation in contour-related complications, rather than as evidence that all grafting techniques are equally risky.

The process of aesthetic assessment requires more careful consideration. The two-dimensional distance

outcomes are based on photographic standardization and are not direct measures of retained volume, contour symmetry or perceived appearance. Standardization with an SMD can be performed for different numerical scales, but cannot be used to make fundamentally different measurements interchangeable. The tear-trough CI with Hartung–Knapp adjustment is much wider, highlighting the uncertainty that comes from combining just three studies. Similarly, the Barton scale is ordinal and the use of change scores and postoperative scores assumes that the scale is interval, which cannot be fully explored from summary data. A three-dimensional assessment can be used in addition to traditional photography [30], and validated patient-reported measures can capture aspects that are not measured by a geometric endpoint. The FACE-Q eye module has been validated for this use, but in each trial, language and population suitability should be taken into account [35].

Also, the lack of a revision difference does not mean that the downstream treatment burden is the same. Revision involved various reasons such as unsatisfactory correction, contour irregularity, and residual puffiness. These decisions may be based on patient expectations, surgeon thresholds, and willingness to undergo another procedure. Technical reports of combined lower blepharoplasty and fat injection highlight that the correction should be personalized and that additional fat injection should be selective [36]. In a similar vein, a series that utilized a skin flap technique included conservative fat management, muscle sparing, and microfat grafting as part of a larger rejuvenation plan [37]. These procedures may yield acceptable results but can be confusing when considering revision rates for each technique. Similar reporting should differentiate between the staged augmentation performed as a planned procedure versus the corrective surgery performed as an unplanned procedure, and whether the staged augmentation was for the tear trough, skin or another part of the surgery.

There is also general evidence that suggests that the surgical access incision should not be considered a proxy for the actual surgical procedure. A recent review of fat-preserving lower blepharoplasty concluded that either transcutaneous or transconjunctival blepharoplasty could be performed, but noted the lack of rigorous outcome reporting [13]. The access route influences the visualization and the dissection options, but does not fully define the treatment that is provided. Other volume-enhancing techniques such as orbital septum reinforcement with acellular dermal matrix have been explored as well [38]. These methods were not included in this comparison and cannot be recommended based on our results. However, they show that correction can be made by changing the support of the tissues, as well as by the transposition or transfer of fat. A useful comparative trial should thus be formulated in such a way that the operative parts are clearly defined so that the results can be reproduced and applied.

The evidence should also be considered in the broader context of the available treatments for tear-trough depression. Anatomically directed management has always been a focus on the fact that a hollow may need to be filled with volume, moved, or supported structures may need to be corrected [39]. A recent systematic review of the indirect comparison of hyaluronic acid fillers and autologous fat grafting revealed high reported satisfaction rates, but no strong comparative safety evidence, based on the heterogeneous single-arm evidence [40]. That review does not address the issue of repositioning versus grafting, but it reinforces a common issue: apparently good results within a series of treatments do not necessarily mean that the same treatment is best for an individual patient. Direct comparisons should maintain a clear clinical indication, and differentiate between isolated volume deficiency and fat prominence, skin excess, and modified eyelid support.

Limitations

The results are limited by several factors. Only five studies were included, and most outcomes were based on three or four studies, four of which were non-randomized and subject to confounding by indication and surgeon selection. The assessments provided indicated some concerns in the trial and moderate overall risk of bias in the observational studies, which do not preclude residual confounding. Graft source, access route, fixation, age, and measurement methods were not independent and therefore interpretation of subgroups was limited. Hedén et al. excluded significant numbers from photographic assessment and the report is ambiguous in regards to ten mixed-treatment cases. Chiu et al. contributed eye-level data without a documented clustering adjustment; changing its denominator for Barton sensitivity analysis does not by itself resolve correlated outcomes. The source materials did not include analysis scripts for independent verification and median-based conversions were used without a documented algorithm. The rate of follow-up was mainly one year, the number of complications was very small, and there was no reliable assessment of publication bias. The patients in the Chinese cohort were younger than those in the European and Iranian cohorts, so that extrapolation to all anatomical presentations was not possible. No formal certainty-of-evidence assessment was supplied.

Clinical implications

Clinically, these data favor a discussion of trade-offs tailored to the patient's anatomy and priorities. Repositioning can be appealing if there is accessible orbital fat to bridge the depression, and grafting can provide options for the amount and location of augmentation. These considerations are based on the principles of operation and the literature available and not from a validated selection algorithm from this meta-analysis. Patients should be informed that there is no proven overall aesthetic benefit, that there are different types of grafting, and that the decrease in nodules with repositioning is not guaranteed. In future multicenter trials, it is important to standardize the graft source, the operative plane, the fixation, the photography, the definition of adverse events, and the assessment times. They should prespecify patient-level analyses and/or adjust for eye-level correlation, attempt to have blinded assessment where possible, include validated patient-

reported outcomes, and follow patients long enough to assess resorption, recurrent bulging, and additional surgery.

Conclusion and Future Research

Current comparative evidence does not establish a consistent aesthetic advantage of orbital fat repositioning over autologous fat grafting, or vice versa, for lower eyelid and tear-trough correction. Fewer nodules or induration were associated with repositioning, a finding that was study dependent. Aesthetic results are difficult to interpret because of variation in graft source and the methods of measurement. These uncertainties should be taken into account, and treatment should be individualized. Future randomized trials should evaluate well-defined techniques, consider paired eyes, and evaluate patient satisfaction and clinically relevant complications and durability over longer follow-up.

Conflict of interest

The authors declare that they don't have any conflicts of interest regarding this study.

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Ethical approval

No ethical approval was required for this study, as it is a PRISMA-compliant systematic review and meta-analysis. The protocol of this study was prospectively registered with PROSPERO to maintain transparency.

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Supplementary content (if any) is available online.

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