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Efficacy and safety of four-point scleral fixation of intraocular lenses in eyes without adequate capsular support: a systematic review and meta- analysis

Joanna Dolar-Szczasny

Joanna.Dolar-Szczasny@umlub.edu.pl

Medical University of Lublin https://orcid.org/0000-0003-4206-4371

Agnieszka Drab

Medical University of Lublin https://orcid.org/0000-0002-4864-0184

Robert Rejdak

Medical University of Lublin https://orcid.org/0000-0003-3321-2723

Systematic Review

Keywords: Four-point fixation, Scleral-fixated intraocular lens, Secondary intraocular lens, Aphakia, Gore-Tex, Polypropylene suture, Flanged technique, Meta-analysis

Posted Date: November 19th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11775733/v1

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Additional Declarations: The authors declare no competing interests.

Abstract

Background

Four-point scleral fixation is increasingly used for secondary intraocular lens (IOL) implantation in eyes without adequate capsular support, yet pooled estimates of its visual benefit and complication profile are lacking. We aimed to quantify visual outcomes and postoperative complications after four-point scleral IOL fixation.

Methods

This systematic review was conducted according to PRISMA 2020 and registered retrospectively in OSF Registries (doi:10.17605/OSF.IO/DTY7X). The final searches of PubMed, Embase, Europe PMC and the Cochrane Library (CENTRAL) were completed on 5 November 2026. Studies of ≥ 4 eyes undergoing sutured or flanged four-point scleral fixation of a posterior chamber IOL were included. Within-study changes in logMAR visual acuity and intraocular pressure (IOP) were pooled with random-effects models (REML with Hartung-Knapp adjustment), and complication incidences with random-intercept logistic generalized linear mixed models. Risk of bias was assessed with RoB 2 and an adapted Newcastle-Ottawa Scale, and certainty of evidence with GRADE.

Results

Sixty-seven studies (approximately 3,250 eyes; two randomized) were included. Best-corrected visual acuity improved by 0.57 logMAR (95% CI 0.44–0.70; 37 studies, 1,552 eyes; I^2 = 97%) and uncorrected distance visual acuity by 0.83 logMAR (95% CI 0.53–1.14; 7 studies, 211 eyes). Results were robust in sensitivity analyses and did not differ by suture material or technique (p = 0.56). Mean IOP fell slightly (0.97 mmHg, 95% CI 0.02–1.93; 17 studies). The most frequent complications were ocular hypertension (15.9%, 95% CI 12.4–20.3), cystoid macular oedema (10.1%, 7.2–14.0), corneal oedema (9.9%, 5.3–17.7) and hypotony (7.5%, 5.1–10.9). Other pooled incidences were glaucoma (4.2%), vitreous haemorrhage (4.3%), IOL tilt/decentration (2.4%), retinal detachment (1.5%), IOL dislocation (1.3%), endophthalmitis (0.7%) and suture-related complications (0.8%). Certainty of evidence was very low across all assessed outcomes.

Conclusions

Four-point scleral fixation of posterior chamber IOLs was associated with improved visual acuity and a low incidence of serious postoperative complications, including retinal detachment, IOL dislocation and endophthalmitis. Ocular hypertension and cystoid macular oedema were among the most frequently reported complications, highlighting the importance of postoperative monitoring. However, the very low certainty of the available evidence limits the strength of these conclusions. Further prospective comparative studies with standardized outcome definitions and long-term follow-up are warranted to better define the efficacy and safety of four-point fixation relative to alternative IOL fixation techniques.

Background

Eyes without adequate capsular support after complicated cataract surgery, trauma, intraocular lens (IOL) dislocation or hereditary lens subluxation require alternative strategies for IOL implantation. Options include anterior chamber IOLs, iris-fixated IOLs, sutured scleral fixation and sutureless intrascleral haptic fixation [1]. Scleral fixation places the optic close to the anatomical position of the crystalline lens, but conventional two-point fixation can be complicated by IOL tilt, decentration, pupillary optic capture and suture degradation [1, 8].

Four-point fixation, in which the IOL is anchored to the sclera at four sites, was proposed to improve centration and reduce tilt [2, 3]. The technique has evolved from ab externo polypropylene suturing [3, 4] to flapless and knotless variants [5], polytetrafluoroethylene (PTFE; Gore-Tex) sutures used with four-eyelet IOLs such as the Akreos AO60 [7], and four-flanged

polypropylene techniques that avoid knots altogether [6, 30, 31]. Sutureless intrascleral haptic fixation (the Yamane technique) is faster, but relies on two support points [9].

Previous meta-analyses compared sutured and Yamane fixation [10] or scleral and iris fixation [11], but did not provide pooled estimates specific to four-point fixation. The aim of this systematic review and meta-analysis was therefore to quantify the change in visual acuity and the incidence of postoperative complications after four-point scleral IOL fixation, and to explore whether outcomes differ by suture material and fixation technique.

Methods

Protocol and registration

This systematic review was conducted in accordance with the PRISMA 2020 guidelines [12] (Additional file 1). The review protocol was retrospectively registered in OSF Registries on 4 November 2026 (Generalized Systematic Review Registration; DOI: 10.17605/OSF.IO/DTY7X).

The following methodological decisions were specified during the review process: (i) eligibility included all sutured (PTFE or polypropylene) and flanged four-point techniques, including refixation of dislocated four-haptic IOLs; (ii) the minimum sample size was set at 4 eyes, with a sensitivity analysis restricted to studies with ≥ 10 eyes; (iii) visual acuity and IOP were analysed as within-study mean changes, and proportions were pooled with a generalized linear mixed model; (iv) subgroup analyses by suture material and technique were conducted; and (v) non-randomized studies were assessed with an adapted Newcastle-Ottawa Scale and certainty of evidence was rated with GRADE.

Eligibility criteria

Population: eyes of patients of any age with aphakia, dislocated IOL or subluxated crystalline lens lacking adequate capsular support. Intervention: four-point scleral fixation of a posterior chamber IOL – implantation of a new IOL or refixation of a dislocated IOL at four scleral points – either sutured (polypropylene or PTFE) or flanged. Comparator: none required; when a study compared four-point fixation with another technique, only the four-point arm was used in the pooled single-arm analyses, and the comparison was summarised narratively. Outcomes: preoperative and postoperative visual acuity, IOP and postoperative complications. Randomized trials, cohort studies and case series with at least four eyes were eligible. Surgical technique descriptions without outcome data, case reports, studies of two-point fixation, fixation of the capsular bag–IOL complex or of capsular tension devices, and studies in which four-point fixation could not be confirmed or separated from other techniques were excluded.

Information sources and search strategy

The final database searches were completed on 5 November 2026. The last searches were conducted in PubMed on 3 November 2026, in Europe PMC (including records not indexed in MEDLINE and preprints) on 4 November 2026, and in Embase (Embase.com, including conference abstracts and trial registry records) and the Cochrane Library (CENTRAL, Issue 11 of 12, November 2026) on 5 November 2026. The search combined free-text terms and MeSH headings for four-point/4-point/four-flanged/four-haptic fixation, scleral/intrascleral/transscleral fixation, intraocular lens and aphakia, and for Akreos and Gore-Tex/polytetrafluoroethylene combined with scleral fixation. Reference lists of relevant studies and systematic reviews were hand-searched. Full search strings and the record-level screening log are provided in Additional file 2. Only reports published in English were included.

Study selection and data extraction

Two reviewers (JDS, AD) independently screened titles and abstracts and then the full texts of all reports retrieved for eligibility assessment; disagreements were resolved by a third reviewer (RR). Data were extracted by one reviewer (JDS) and checked by

the second (AD); risk of bias was assessed by JDS. Data were extracted into a standardized spreadsheet: study design, number of eyes, indication, IOL model, suture material, fixation technique, concomitant procedures (pars plana vitrectomy, keratoplasty), follow-up, preoperative and postoperative visual acuity (mean and standard deviation, SD), IOP and complications. Data were extracted from retrieved full-text reports or, for conference records without an eligible full-text publication, from the complete published conference abstract. Conference abstracts were retained as separate reports when no conclusive evidence of overlap with an included full-text study was identified. Potential overlap was considered where information was available; reports were not merged or excluded solely on the basis of similarity in technique, IOL model, authorship or population without specific evidence that they represented the same or partially overlapping cohorts. Their contribution to complication-specific meta-analyses was restricted to outcomes for which extractable data were available. Snellen and decimal acuities were converted to logMAR; when decimal means and SDs were reported, logMAR values were approximated by the delta method, counting fingers was assigned 1.9 logMAR, and when individual patient data were reported, means and SDs were calculated from them. When the same cohort was reported more than once, each outcome was taken from one report only.

Randomized trials were assessed with the Cochrane RoB 2 tool [13] and non-randomized studies with the Newcastle-Ottawa Scale (NOS) [14], adapted for single-arm series (maximum 9 stars; good ≥ 7, fair 5–6, poor ≤ 4). Item-level assessments are given in Additional file 3, and the overall rating of each study is shown in Table 1. Certainty was assessed separately for each outcome using the five GRADE domains: risk of bias, inconsistency, indirectness, imprecision and publication bias [18] (Table 4; detailed domain-level judgements in Additional file 3). The non-randomized evidence base was initially rated low certainty. Risk of bias was judged separately for each outcome by linking the contributing studies to their study-level adapted NOS or RoB 2 assessments; no automatic downgrade was applied solely because a study was rated fair or because a single-arm study lacked a comparability star. No upgrading was applied. Publication bias was assessed with Egger's regression test for continuous outcomes with at least 10 studies (BCVA and IOP); it was not formally assessed for UDVA (7 studies) or for complication incidences, for which small-study-effect tests are unreliable with single-arm proportions and rare events.

Table 1
Characteristics of included studies

Study	Design	Eyes	Suture / technique / IOL	Population	Source	Quality: adapted NOS (stars) / RoB 2
Sewelam 2003 [3]	Retrospective series	20	Polypropylene, sutured (ab externo)	Children, aphakia	Previously identified study	Fair (6)
Raina 2022 [19]	Randomized pilot study	20	PTFE, Akreos AO60	Adults	Previously identified study	RoB 2: Some concerns
Botsford 2019 [20]	Retrospective series	31	PTFE; Akreos AO60 (23) / CZ70BD (8)	Adults	Previously identified study	Excluded: 8 eyes two-point (CZ70BD), outcomes not separable
Lodhi 2018 [21]	Case series	30	Polypropylene, sutured	Adults	Previously identified study	Fair (6)
Zhu 2024 [22]	Retrospective multicentre series	192	Polypropylene closed loop, Akreos Adapt	Adults	Previously identified study	Good (9)
Terveen 2016 [23]	Retrospective series	37	Polypropylene or PTFE, Akreos AO60	Adults	Previously identified study	Good (7)
Patel 2020 [24]	Retrospective series	63	PTFE, Akreos AO60	Adults	Previously identified study	Good (8)
Narayanan 2023 [25]	Retrospective series	42	Polypropylene, Hoffman pocket + PKP	Corneal disease	Previously identified study	Fair (6)
Pao 2024 [26]	Retrospective series	10	PTFE + PPV	Adults	Previously identified study	Fair (6)
Almashad 2010 [4]	Retrospective series	15	Polypropylene, flapless	Adults	Previously identified study	Fair (6)
Gao 2022 [27]	Retrospective comparative (vs 2-point)	23 (4-point arm)	Polypropylene closed loop, Akreos Adapt	Marfan syndrome	Previously identified study	Good (8)
Błagun 2024 [28]	RCT (vs Yamane)	25 (4-point arm)	Polypropylene, Akreos AO60	Adults	Previously identified study	RoB 2: Some concerns
Canabrava 2020 [30]	Case series	4	Four-flanged polypropylene 5 – 0	Adults	Previously identified study	Fair (6)

NOS, Newcastle-Ottawa Scale; PKP, penetrating keratoplasty; PMMA, polymethyl methacrylate; PPV, pars plana vitrectomy; PTFE, polytetrafluoroethylene (Gore-Tex); RCT, randomized controlled trial. Source identifies the report used for study-level data extraction. NOS ratings: good ≥ 7, fair 5–6, poor ≤ 4 stars. Rows marked “Excluded” are shown for transparency and were not included in the analyses.

Study	Design	Eyes	Suture / technique / IOL	Population	Source	Quality: adapted NOS (stars) / RoB 2
Evereklioglu 2003 [29]	Retrospective comparative	51	Polypropylene; CZ70BD (two eyelets)	Adults	Previously identified study	Excluded: two-point fixation (CZ70BD)
Canabrava 2021 [31]	Case series	7	Four-flanged polypropylene 6 – 0	Adults	Previously identified study	Fair (5)
Vivekanandan 2023 [32]	Case series	103	Four-flanged polypropylene 7 – 0, PMMA	Adults	Previously identified study	Fair (6)
Patel 2018 [33]	Retrospective series	49	PTFE, Akreos AO60	Adults	Current search – full-text report	Fair (6)
Pardini 2023 [34]	Retrospective multicentre series	101	PTFE, Akreos AO60 + PPV	Adults	Current search – full-text report	Fair (6)
Pardini 2025 [35]	Prospective series	7	PTFE, Akreos AO60 + PPV	Adults	Current search – full-text report	Fair (5)
Junqueira 2021 [36]	Prospective series	20	PTFE, Akreos AO60	Adults	Current search – full-text report	Fair (6)
Leuzinger-Dias 2021 [37]	Retrospective series	37	PTFE, Akreos AO60 + PPV	Adults	Current search – full-text report	Fair (5)
Hind 2025 [38]	Retrospective series	105	PTFE, Akreos / Micropure	Adults	Current search – full-text report	Fair (5)
Chen S 2023 [39]	Retrospective series	15	Polypropylene 9 – 0 double strand, Akreos Adapt	Adults	Current search – full-text report	Fair (5)
Chen C 2025 [40]	Retrospective series	12	Polypropylene 8 – 0 loop/sliding knot, Akreos Adapt	Adults	Current search – full-text report	Fair (5)
Liu 2023 [41]	Retrospective series	22	Polypropylene 9 – 0, four-loop IOL	Adults	Current search – full-text report	Fair (5)
Ha 2026 [42]	Retrospective series	20	Four-flanged polypropylene 6 – 0	Adults	Current search – full-text report	Fair (5)

NOS, Newcastle-Ottawa Scale; PKP, penetrating keratoplasty; PMMA, polymethyl methacrylate; PPV, pars plana vitrectomy; PTFE, polytetrafluoroethylene (Gore-Tex); RCT, randomized controlled trial. Source identifies the report used for study-level data extraction. NOS ratings: good ≥ 7, fair 5–6, poor ≤ 4 stars. Rows marked “Excluded” are shown for transparency and were not included in the analyses.

Study	Design	Eyes	Suture / technique / IOL	Population	Source	Quality: adapted NOS (stars) / RoB 2
Ghazi 2025 [44]	Retrospective series	8	Four-flanged polypropylene, enVista MX60	Adults	Current search – full-text report	Fair (5)
John 2018 [45]	Case series	9	Polypropylene 8 – 0 (3 eyes with PKP)	Adults	Current search – full-text report	Poor (3)
Hauser 2021 [46]	Comparative series (prophylaxis)	26	PTFE + PPV	Pseudoexfoliation	Current search – full-text report	Good (7)
Chalam 2026 [47]	Retrospective series	172	PTFE, Akreos AO60 + PPV	Adults	Current search – full-text report	Fair (5)
Sen 2018 [48]	Retrospective series	279	Polypropylene 10 – 0, ab externo + PPV	Children	Current search – full-text report	Fair (5)
Shah 2021 [53]	Retrospective series	52	PTFE, Akreos AO60	Adults (trainee surgeons)	Current search – full-text report	Fair (6)
Goel 2018 [56]	Retrospective series	20	Polypropylene 9 – 0, Akreos AO60 + PPV	Adults	Current search – full-text report	Fair (6)
Cho 2026 [51]	Retrospective comparative (vs Yamane)	120 (4-point arm)	Polypropylene 9 – 0/10 – 0 closed loop	Adults	Current search – full-text report	Good (8)
Poh 2026 [50]	Retrospective comparative (vs flanged intrascleral)	57 (4-point arm)	PTFE, Akreos AO60 / Adapt AO	Adults	Current search – full-text report	Good (7)
Park 2026 [57]	Retrospective series	12	Four-flanged polypropylene, trans-ocular threading	Adults	Current search – full-text report	Fair (5)
Xu 2026 [58]	Prospective series	5	Polypropylene, four-haptic IOL + PKP	Corneal disease	Current search – full-text report	Fair (5)
Kim S 2026 [59]	Retrospective series	22	Polypropylene 10 – 0, single-loop 4-point	Secondary angle closure from lens subluxation	Current search – full-text report	Poor (4)
Jiang 2026 [60]	Retrospective series	9	Polypropylene closed loop,	Dislocated IOL (refixation)	Current search –	Fair (5)

NOS, Newcastle-Ottawa Scale; PKP, penetrating keratoplasty; PMMA, polymethyl methacrylate; PPV, pars plana vitrectomy; PTFE, polytetrafluoroethylene (Gore-Tex); RCT, randomized controlled trial. Source identifies the report used for study-level data extraction. NOS ratings: good ≥ 7, fair 5–6, poor ≤ 4 stars. Rows marked “Excluded” are shown for transparency and were not included in the analyses.

Study	Design	Eyes	Suture / technique / IOL	Population	Source	Quality: adapted NOS (stars) / RoB 2
			Akreos refixation		full-text report	
Zhang J 2025 [61]	Retrospective series	17	Polypropylene 8 – 0 closed loop, Akreos Adapt refixation	Dislocated IOL (refixation)	Current search – full-text report	Fair (5)
Michaels 2024 [62]	Retrospective series	7	PTFE, Akreos Adapt refixation	Dislocated IOL (refixation)	Current search – full-text report	Fair (5)
Agrawal 2025 [63]	Prospective series	33	Four-flanged polypropylene (laser flange)	Adults	Current search – full-text report	Fair (6)
Chen H 2024 [64]	Retrospective series	14	Flanged polyglactin 6 – 0, four-point	Adults	Current search – full-text report	Fair (5)
Mishra 2024 [65]	Retrospective series	783	PTFE, Akreos AO60 + PPV	Adults	Current search – full-text report	Fair (5)
Silva 2022 [66]	Retrospective series	99	Polypropylene 9 – 0/10 – 0 knotless zigzag, Akreos AO60	Adults	Current search – full-text report	Fair (6)
Kim DW 2022 [67]	Retrospective series	9	Polypropylene 8 – 0, enVista MX60 eyelets	Adults	Current search – full-text report	Fair (5)
Wang Z 2019 [68]	Retrospective series	18	Polypropylene, 4-point foldable IOL	Marfan syndrome	Current search – full-text report	Fair (6)
Zyablitskaya 2022 [69]	Retrospective comparative (vs 2-point sutureless)	24 (4-point arm)	PTFE, Akreos AO60 + PPV	Adults	Current search – full-text report	Good (7)
Shin 2018 [70]	Retrospective comparative (vs 2-point)	7 (4-point arm)	Polypropylene, three-piece IOL	Adults	Current search – full-text report	Fair (6)
Liu Q 2025 [71]	Retrospective series	5	Polypropylene 8 – 0 closed loop, Akreos refixation	Dislocated IOL (refixation)	Current search – full-text report	Fair (5)
Day 2020 / 2025 [72, 73]	Retrospective series (two reports)	27 / 98	PTFE, Akreos AO60 + PPV	Adults	Current search – full-text report	Fair (5)

NOS, Newcastle-Ottawa Scale; PKP, penetrating keratoplasty; PMMA, polymethyl methacrylate; PPV, pars plana vitrectomy; PTFE, polytetrafluoroethylene (Gore-Tex); RCT, randomized controlled trial. Source identifies the report used for study-level data extraction. NOS ratings: good ≥ 7, fair 5–6, poor ≤ 4 stars. Rows marked “Excluded” are shown for transparency and were not included in the analyses.

Study	Design	Eyes	Suture / technique / IOL	Population	Source	Quality: adapted NOS (stars) / RoB 2
Dubinsky-Pertzov 2024 [74]	Retrospective comparative (vs ACIOL)	32 (4-flanged arm)	Four-flanged polypropylene	Adults	Current search – full-text report	Good (8)
Boz 2023 [75]	Retrospective comparative (three techniques)	27 (4-flanged arm)	Four-flanged polypropylene	Adults	Current search – full-text report	Good (7)
Chan 2026 [76]	Retrospective series	53	PTFE, four-point sutured	Children	Current search – full-text report	Fair (6)
Pineda-Fernández 2021 [77]	Case series	7	PTFE transfixion of optic	Adults	Current search – full-text report	Poor (4)
Hu 2020 [5]	Retrospective series	11	Polypropylene 8 – 0, intrascleral anchoring	Adults	Current search – full-text report	Fair (5)
Hu 2021 [85]	Case series	4	Polypropylene 8 – 0, intraocular looping refixation	Dislocated IOL (refixation)	Current search – full-text report	Poor (4)
Byun 2025 [49]	Retrospective comparative (three techniques)	24 (4-point arm)	Polypropylene double-armed	Adults	Current search – full-text report	Good (8)
Baykara 2004 [78]	Prospective series	50	Polypropylene, 4-point ab externo	Adults	Current search – full-text report	Fair (6)
Lin 2004 [79]	Case series	10	Polypropylene suture fixation	Adults	Current search – full-text report	Poor (4)
Chakrabarti 1999 [80]	Prospective comparative	25	Polypropylene, ab externo 4-point	Adults	Current search – full-text report	Good (7)
Fass 2010 [81]	Case series	9	Polypropylene, hydrophilic acrylic IOL	Adults	Current search – full-text report	Poor (4)
Tan 2026 [82]	Retrospective series	9	Polypropylene 10 – 0 looped, four-looped IOL	Adults	Current search – full-text report	Poor (4)
Angsana 2023 [83]	Case series	6	Polypropylene 8 – 0, PMMA 2-	Adults	Current search –	Poor (4)

NOS, Newcastle-Ottawa Scale; PKP, penetrating keratoplasty; PMMA, polymethyl methacrylate; PPV, pars plana vitrectomy; PTFE, polytetrafluoroethylene (Gore-Tex); RCT, randomized controlled trial. Source identifies the report used for study-level data extraction. NOS ratings: good ≥ 7, fair 5–6, poor ≤ 4 stars. Rows marked “Excluded” are shown for transparency and were not included in the analyses.

Study	Design	Eyes	Suture / technique / IOL	Population	Source	Quality: adapted NOS (stars) / RoB 2
			eyelet IOL at 4 points		full-text report	
Belkin 2026 [84]	Prospective series	15	Flanged, toric plate-haptic IOL	Adults	Current search – full-text report	Fair (5)
Wu 2020 [86]	Case series	4	Polypropylene (not stated), Akreos AO60 refixation, buried sutures	Dislocated IOL (refixation)	Current search – full-text report	Fair (5)
Nofal 2018 [87]	Retrospective series (conference abstract)	56	PTFE, Akreos AO60	Adults	Current search – conference abstract	Fair (5)
Laham 2017 [88]	Retrospective comparative (conference abstract)	14 (Akreos arm)	PTFE, Akreos AO60 + PPV	Adults	Current search – conference abstract	Fair (5)
Zukerman 2023 [89]	Retrospective series (conference abstract)	8	PTFE, Akreos AO60 + PPV	Ectopia lentis	Current search – conference abstract	Fair (5)

NOS, Newcastle-Ottawa Scale; PKP, penetrating keratoplasty; PMMA, polymethyl methacrylate; PPV, pars plana vitrectomy; PTFE, polytetrafluoroethylene (Gore-Tex); RCT, randomized controlled trial. Source identifies the report used for study-level data extraction. NOS ratings: good ≥ 7, fair 5–6, poor ≤ 4 stars. Rows marked “Excluded” are shown for transparency and were not included in the analyses.

Table 4

GRADE summary of findings: four-point scleral fixation of a posterior chamber IOL in eyes without adequate capsular support
Domain key: risk of bias, inconsistency, indirectness, imprecision and publication bias were judged separately for each outcome; full domain rationales are provided in Additional file 3. Non-randomized single-arm evidence started at low certainty and no upgrading was applied. The risk-of-bias domain was judged outcome-specifically from the contributing studies' adapted NOS and RoB 2 ratings; serious concerns were assigned for IOL tilt/decentration, IOL dislocation and endophthalmitis. Publication bias was assessed with Egger's test for BCVA and IOP; for the other outcomes it was not formally assessed, which does not mean that publication bias is absent.

Outcome	Studies (eyes)	Estimate (95% CI)	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall
BCVA change	37 (1,552)	0.57 (0.44–0.70)	Not serious	Very serious	Not serious	Not serious	Undetected (Egger p = 0.45)	Very low
UDVA change	7 (211)	0.83 (0.53–1.14)	Not serious	Serious	Not serious	Serious	Not assessed	Very low
IOP change	17 (448)	0.97 (0.02–1.93)	Not serious	Serious	Not serious	Serious	Undetected (Egger p = 0.08)	Very low
Ocular hypertension	25 (2,093)	15.94% (12.36–20.31)	Not serious	Serious	Not serious	Not serious	Not assessed	Very low
Corneal oedema	18 (763)	9.90% (5.30–17.74)	Not serious	Very serious	Not serious	Serious	Not assessed	Very low
Cystoid macular oedema	35 (2,186)	10.09% (7.15–14.05)	Not serious	Serious	Not serious	Not serious	Not assessed	Very low
Hypotony	26 (1,902)	7.47% (5.07–10.88)	Not serious	Serious	Not serious	Not serious	Not assessed	Very low
Glaucoma	10 (666)	4.15% (1.62–10.25)	Not serious	Very serious	Not serious	Serious	Not assessed	Very low
Vitreous haemorrhage	26 (2,032)	4.26% (2.89–6.24)	Not serious	Serious	Not serious	Not serious	Not assessed	Very low
IOL tilt/decentration	26 (715)	2.37% (1.31–4.25)	Serious	Not serious	Serious	Serious	Not assessed	Very low
Retinal detachment	34 (2,239)	1.48% (0.83–2.61)	Not serious	Not serious	Not serious	Serious	Not assessed	Very low
IOL dislocation	25 (1,710)	1.26% (0.54–2.90)	Serious	Serious	Not serious	Serious	Not assessed	Very low
Endophthalmitis	21 (1,650)	0.73% (0.41–1.28)	Serious	Not serious	Not serious	Serious	Not assessed	Very low
Suture-related complications	36 (2,032)	0.81% (0.27–2.36)	Not serious	Serious	Not serious	Serious	Not assessed	Very low

BCVA, best-corrected visual acuity; IOP, intraocular pressure; UDVA, uncorrected distance visual acuity.

Effect measures and synthesis

For visual acuity, the effect measure was the within-study mean change from baseline (preoperative minus postoperative logMAR; positive values indicate improvement). When studies did not report the SD of the change, it was derived assuming a pre–post correlation of r = 0.5, with sensitivity analyses at r = 0.3 and r = 0.7 [17]; when the mean change and its SD were reported directly, these were used. IOP change was analysed in the same way (positive values indicate a reduction). Changes were pooled with random-effects models using restricted maximum likelihood estimation of τ^2 and the Hartung-Knapp adjustment, and 95% prediction intervals were calculated.

Complication incidences (events/eyes) were pooled per complication with a random-intercept logistic generalized linear mixed model (GLMM) [16], which retains studies with zero events and avoids confidence limits below zero. A complication was included for a study only when its occurrence or explicit absence was reported. Results were not pooled across different outcomes.

Heterogeneity was quantified with I^2 and τ^2. Subgroup analyses compared suture material and technique (PTFE sutured, polypropylene sutured, flanged) using meta-regression. Sensitivity analyses for visual acuity and IOP comprised leave-one-out analyses; alternative pre–post correlations (r = 0.3 and 0.7); restriction to studies with ≥ 10 eyes; exclusion of IOL refixation series, of studies with approximated acuity, of possibly overlapping cohorts and of a study with internally inconsistent values; and re-inclusion of a mixed two-/four-point series. For complication incidences, sensitivity analyses excluded IOL refixation populations and the potentially overlapping Day et al. 2025 cohort. Small-study effects were assessed with Egger's regression only for outcomes with ≥ 10 studies. Analyses were performed in R with the metafor package [15] (continuous outcomes: R 4.3.3, metafor 4.4; complication incidences: R 4.6.2, metafor 5.2.1 and lme4); the analysis scripts and datasets are provided in Additional file 4.

Results

Study selection

The searches identified 489 records (PubMed 195, Embase 264, Europe PMC 17 and Cochrane CENTRAL 13). After removal of 194 duplicate records and 13 records removed before screening (12 reports of studies already represented in the review and one additional record removed at deduplication), 282 records were screened and 132 were excluded. The full texts of 150 reports were sought and retrieved, and all 150 were assessed for eligibility; for conference records, the complete published conference abstract was assessed as the report. Ninety-four reports were excluded, most often because four-point fixation could not be confirmed or separated from other techniques (n = 47) or because no usable outcome data were reported (n = 23). Fifty-three newly identified studies (54 reports), together with two additional reports relating to an included trial, were incorporated. In total, 67 studies (69 reports; approximately 3,250 eyes) were included. Thirty-nine studies contributed visual acuity data, 17 IOP data and 61 complication data (Fig. 1).

Study characteristics and risk of bias

Study characteristics are summarised in Table 1. Two randomized studies were included (Błagun et al. [28]; Raina et al. [19]); ten further studies were non-randomized comparisons, and the remaining studies were retrospective or prospective case series, with sample sizes from 4 to 783 eyes. Twenty-two studies used PTFE sutures, mostly with the Akreos AO60 IOL, 33 used sutured polypropylene (including closed-loop and knotless variants), 11 used flanged techniques and one used either suture. Six series reported refixation of a dislocated four-haptic IOL [60–62, 71, 85, 86]. Two studies were confined to children [3, 48] and one further series to paediatric eyes [76], two to Marfan syndrome [27, 68] and one to ectopia lentis [89], one to pseudoexfoliation [46], two combined fixation with penetrating keratoplasty [25, 58] and one included eyes with acute secondary angle closure [59]. Both randomized studies were judged to have some concerns (RoB 2), mainly because outcome assessors could not be masked. Of the non-randomized studies, 12 were rated good, 45 fair and 8 poor on the adapted NOS (Additional file 3); most lacked a comparison group and adjustment for confounding. Three included cohorts were available only as conference abstracts (Nofal 2018, Laham 2017 and Zukerman 2023); they contributed only to complication-specific analyses for outcomes with extractable data.

Visual outcomes

Best-corrected visual acuity (BCVA) improved by a mean of 0.57 logMAR (95% CI 0.44–0.70; 37 studies, 1,552 eyes; I^2 = 97%; 95% prediction interval − 0.20 to 1.34) (Fig. 2, Table 2), roughly six Snellen lines. The estimate was unchanged with correlations of 0.3 and 0.7 (0.57 and 0.57), and leave-one-out estimates ranged from 0.53 to 0.59; the most influential study was a small keratoplasty series with a baseline of 3.0 logMAR in all eyes [58] (0.53, 0.42–0.63, without it). Restricting the analysis to studies with ≥ 10 eyes gave 0.53 (0.43–0.64; 29 studies) and to full-text data 0.64 (0.47–0.80; 27 studies); excluding IOL refixation series gave 0.55 (0.42–0.69), excluding the two studies with approximated acuity [30, 45] 0.57 (0.44–0.70), excluding a possibly overlapping cohort [33] 0.57 (0.44–0.71) and excluding a study with internally inconsistent values [47] 0.56 (0.43–0.69). Studies identified in the initial search alone gave 0.37 (0.20–0.55; 6 studies), and re-including the mixed two-/four-point series [20] gave 0.58 (0.45–0.71). Improvement was similar with PTFE sutures (0.64, 0.44–0.83; 12 studies) and sutured polypropylene (0.57, 0.35–0.78; 20 studies) and smaller with flanged techniques (0.39, 0.20–0.58; 5 studies), but the difference was not significant (meta-regression p = 0.56) and largely reflected better baseline acuity in the flanged series. Egger's test did not suggest small-study effects (p = 0.45). Two large series reported acuity in a form that could not be pooled: a mean gain of 35 ETDRS letters at ≥ 3 months in 439 eyes after PTFE fixation of the Akreos AO60 [65], and median improvement in 53 paediatric eyes [76].

Table 2
Pooled change in visual acuity and intraocular pressure (random-effects, REML with Hartung-Knapp adjustment)

Outcome	Analysis	Studies	Eyes	Mean change (95% CI)	95% PI	I^2 (%)
BCVA	main (r = 0.5), all studies	37	1552	0.57 (0.44 to 0.70)	-0.20 to 1.34	97
BCVA	sensitivity r = 0.3	37	1552	0.57 (0.44 to 0.70)	-0.20 to 1.34	96.2
BCVA	sensitivity r = 0.7	37	1552	0.57 (0.44 to 0.70)	-0.20 to 1.35	97.9
BCVA	studies of the initial search only	6	327	0.37 (0.20 to 0.55)	-0.06 to 0.80	84.9
BCVA	studies with > = 10 eyes	29	1498	0.53 (0.43 to 0.64)	-0.02 to 1.08	95
BCVA	full-text data only	27	1176	0.64 (0.47 to 0.80)	-0.23 to 1.50	97.7
BCVA	excluding IOL refixation series	33	1515	0.55 (0.42 to 0.69)	-0.19 to 1.30	97.1
BCVA	excluding Chalam 2026	36	1380	0.56 (0.43 to 0.69)	-0.21 to 1.33	97
BCVA	excluding Patel 2018 (overlap)	36	1503	0.57 (0.44 to 0.71)	-0.21 to 1.36	97.1
BCVA	subgroup: Gore-Tex sutured	12	534	0.64 (0.44 to 0.83)	-0.03 to 1.30	91.6
BCVA	subgroup: polypropylene sutured	20	935	0.57 (0.35 to 0.78)	-0.40 to 1.53	98.5
BCVA	subgroup: flanged	5	83	0.39 (0.20 to 0.58)	0.01 to 0.78	60.8
UDVA	main (r = 0.5), all studies	7	211	0.83 (0.53 to 1.14)	0.03 to 1.64	91.7
UDVA	sensitivity r = 0.3	7	211	0.83 (0.53 to 1.13)	0.04 to 1.62	89.5
UDVA	sensitivity r = 0.7	7	211	0.84 (0.53 to 1.14)	0.02 to 1.66	94
UDVA	studies of the initial search only	2	30	0.98 (-2.81 to 4.78)	-5.33 to 7.30	87.8
UDVA	full-text data only	5	181	0.79 (0.39 to 1.19)	-0.17 to 1.74	92.8
UDVA	subgroup: Gore-Tex sutured	4	151	0.86 (0.20 to 1.52)	-0.56 to 2.28	94.2
UDVA	subgroup: polypropylene sutured	2	40	0.78 (-2.33 to 3.89)	-4.51 to 6.07	94.3
IOP	main (r = 0.5), all studies	17	448	0.97 (0.02 to 1.93)	-1.98 to 3.92	73.8
IOP	sensitivity r = 0.3	17	448	0.94 (0.01 to 1.87)	-1.82 to 3.70	65.1
IOP	sensitivity r = 0.7	17	448	1.02 (0.04 to 2.00)	-2.17 to 4.22	83.2
IOP	studies of the initial search only	2	215	1.39 (-12.14 to 14.92)	-20.81 to 23.59	84.6
IOP	studies with > = 10 eyes	12	416	1.24 (0.14 to 2.33)	-1.61 to 4.08	74.2
IOP	full-text data only	12	208	1.03 (-0.24 to 2.30)	-2.28 to 4.34	74.6
IOP	excluding IOL refixation series	13	411	1.13 (0.01 to 2.24)	-1.92 to 4.17	75.5

Mean change = preoperative minus postoperative value (logMAR for visual acuity; mmHg for IOP); positive values indicate improvement (visual acuity) or reduction (IOP). PI, prediction interval; r, assumed pre–post correlation.

Uncorrected distance visual acuity (UDVA) improved by 0.83 logMAR (95% CI 0.53–1.14; 7 studies, 211 eyes; I^2 = 92%; prediction interval 0.03–1.64) (Fig. 3); leave-one-out estimates ranged from 0.77 to 0.91.

Intraocular pressure

Seventeen studies (448 eyes) reported mean IOP before and after surgery. Mean IOP decreased slightly, by 0.97 mmHg (95% CI 0.02–1.93; I^2 = 74%; prediction interval − 1.98 to 3.92); leave-one-out estimates ranged from 0.80 to 1.12 mmHg, restriction to studies with ≥ 10 eyes gave 1.24 mmHg (0.14–2.34), and Egger's test was borderline (p = 0.08). One series of eyes with acute secondary angle closure caused by lens subluxation, in which IOP fell from 34.3 to 15.7 mmHg, was not pooled because the indication itself was raised IOP [59]. In patients with Marfan syndrome, IOP rose after two-point fixation but not after four-point fixation [27].

Complications

Pooled incidences of postoperative complications are shown in Fig. 4 and Table 3, with study-level forest plots in Additional file 5. Ocular hypertension was the most frequent complication (15.9%, 95% CI 12.4–20.3; 25 studies, 2,093 eyes; I^2 = 73.5%). Cystoid macular oedema (CME) occurred in 10.1% (95% CI 7.2–14.0; 35 studies, 2,186 eyes; I^2 = 78.8%), corneal oedema in 9.9% (95% CI 5.3–17.7; 18 studies, 763 eyes; I^2 = 85.0%) and hypotony in 7.5% (95% CI 5.1–10.9; 26 studies, 1,902 eyes; I^2 = 69.2%). Glaucoma, including ocular hypertension requiring treatment, was reported in 4.2% (95% CI 1.6–10.2; 10 studies, 666 eyes; I^2 = 80.6%). Vitreous haemorrhage occurred in 4.3% (95% CI 2.9–6.2; 26 studies, 2,032 eyes; I^2 = 53.4%), IOL tilt or decentration in 2.4% (95% CI 1.3–4.2; 26 studies, 715 eyes; I^2 = 12.0%), retinal detachment in 1.5% (95% CI 0.8–2.6; 34 studies, 2,239 eyes; 46 events; I^2 = 35.6%), IOL dislocation in 1.3% (95% CI 0.5–2.9; 25 studies, 1,710 eyes; I^2 = 49.1%), endophthalmitis in 0.7% (95% CI 0.4–1.3; 21 studies, 1,650 eyes; I^2 = 0%) and suture-related complications in 0.8% (95% CI 0.3–2.4; 36 studies, 2,032 eyes; I^2 = 74.9%). Between-study heterogeneity was substantial for several outcomes, particularly corneal oedema, CME, glaucoma, ocular hypertension and suture-related complications. For Sen et al. [48], 15/279 eyes with newly developed postoperative raised IOP were counted as incident ocular hypertension; 20/279 eyes had raised IOP before surgery. Although the authors reported 35/279 eyes requiring antiglaucoma medication in the postoperative period, the 20 pre-existing cases were not counted as incident postoperative events.

Table 3
Pooled incidence of postoperative complications (random-intercept logistic GLMM) Values are pooled proportions from random-intercept logistic generalized linear mixed models (GLMM). k, number of studies contributing data; I^2, percentage of variability attributable to between-study heterogeneity.

Complication	Studies	Eyes	Events	GLMM, % (95% CI)	I^2 (%)
Ocular hypertension	25	2,093	281	15.94 (12.36–20.31)	73.5
Corneal oedema	18	763	98	9.90 (5.30–17.74)	85.0
Cystoid macular oedema	35	2,186	266	10.09 (7.15–14.05)	78.8
Hypotony	26	1,902	143	7.47 (5.07–10.88)	69.2
Glaucoma	10	666	33	4.15 (1.62–10.25)	80.6
Vitreous haemorrhage	26	2,032	73	4.26 (2.89–6.24)	53.4
IOL tilt/decentration	26	715	18	2.37 (1.31–4.25)	12.0
Retinal detachment	34	2,239	46	1.48 (0.83–2.61)	35.6
IOL dislocation	25	1,710	31	1.26 (0.54–2.90)	49.1
Endophthalmitis	21	1,650	12	0.73 (0.41–1.28)	0.0
Suture-related complications	36	2,032	35	0.81 (0.27–2.36)	74.9

GLMM, random-intercept logistic generalized linear mixed model.

Sensitivity analyses for complications are summarised in Additional file 5. Excluding IOL refixation populations had little effect on pooled estimates; retinal detachment was 1.5% (31 studies, 2,213 eyes; 46 events; 95% CI 0.9–2.7). Excluding the potentially overlapping Day et al. 2025 cohort affected only hypotony, changing the estimate to 7.3% (95% CI 4.8–11.0; 25 studies, 1,804 eyes, 135 events), compared with 7.5% (26 studies, 1,902 eyes, 143 events) in the primary analysis.

Comparative studies

Thirteen reports compared four-point fixation with another technique; because the comparators differed (Yamane technique, other flanged intrascleral techniques, two-point fixation, anterior chamber or iris-claw IOLs) they were synthesised narratively, and the four-point arms were included in the pooled analyses where data were extractable. Raina et al. compared four-point PTFE fixation with sutureless flanged fixation in a randomized pilot study [19]. In the randomized trial, BCVA at one year was similar after four-point fixation and the Yamane technique (0.10 ± 0.15 vs 0.09 ± 0.17 logMAR), whereas refractive predictability was better and bleeding was less frequent after four-point fixation [28]; at two years, horizontal and vertical tilt were significantly lower in the four-point group [52]. In a multi-surgeon series of 304 eyes (57 four-point, 247 flanged intrascleral), four-point fixation achieved better BCVA at three months than flanged intrascleral haptic fixation (0.24 ± 0.35 vs 0.37 ± 0.60 logMAR; p = 0.032), with comparable rates of dislocation, optic capture, CME and glaucoma [50]. In 179 eyes (120 four-point closed-loop polypropylene, 59 Yamane), BCVA at six months was similar, operating time was longer with four-point fixation (49.5 vs 35.6 min) and redislocation was less frequent (1.7% vs 8.5%; Yamane hazard ratio 8.68, 95% CI 1.38–54.46) [51]. In a comparison of three techniques, four-point fixation gave the best one-year BCVA (0.06 ± 0.12 logMAR) and less surgically induced astigmatism, at the cost of a longer operation than the sutureless technique [49]. Four-point fixation reduced lens-induced astigmatism compared with two-point fixation [70], and in Marfan syndrome avoided the pupillary capture and IOP rise observed after two-point fixation [27]. Four-flanged fixation was compared with anterior chamber IOLs [74] and with other intrascleral techniques [75], and four-point PTFE fixation with two-point sutureless fixation [69], without consistent differences in visual outcome.

Discussion

This meta-analysis of 67 studies shows that four-point scleral IOL fixation is followed by a mean BCVA gain of about 0.6 logMAR, roughly six Snellen lines, with a low incidence of serious complications such as retinal detachment, dislocation and endophthalmitis. Based on within-study change, mean IOP did not increase after four-point fixation across 17 studies, although transient postoperative ocular hypertension occurs in about one in six eyes.

Heterogeneity in visual outcomes was substantial and is expected. Baseline acuity, indications (aphakia, IOL dislocation, lens subluxation, trauma), concomitant pars plana vitrectomy or keratoplasty, and pre-existing posterior segment disease vary widely across series. The larger gains in PTFE and sutured polypropylene series largely reflect poorer baseline acuity in eyes undergoing combined vitrectomy, and the smaller gain in flanged series their better baseline acuity, rather than an effect of the technique itself; the prediction interval indicates that some settings may achieve little improvement. The modest change in the randomized trial, in which baseline BCVA was already good [28], illustrates this dependence on baseline status.

The theoretical advantage of four-point fixation is mechanical stability. The low pooled incidence of clinically relevant tilt or decentration (2.4%) and of dislocation (1.3%) supports this, as do comparative data showing lower tilt than the Yamane technique at two years [52], a lower hazard of redislocation than the Yamane technique [51] and absence of pupillary capture compared with two-point fixation [27, 54, 70]. The higher dislocation rate in the large paediatric series [48], in which dislocations occurred after a mean of about nine years with 10 – 0 polypropylene, probably reflects long follow-up, suture degradation and ocular growth in children, which supports separate evaluation in this population and the use of more durable sutures. No suture breakage occurred over a mean of 6.7 years after PTFE four-point fixation, although late suture exposure was observed in about one in ten eyes, mostly after concurrent keratoplasty or glaucoma surgery [55]. Several series showed that a dislocated four-haptic IOL can itself be refixated at four points with good visual results [60–62, 71, 85, 86].

Transient ocular hypertension was the most common complication, but most episodes resolved within the first postoperative weeks, and mean IOP was not raised at final follow-up. Glaucoma estimates were imprecise and concentrated in eyes with keratoplasty or trauma. CME rates depended strongly on how CME was ascertained: fluorescein angiography detected CME in a quarter of eyes, mostly subclinical [47], and routine OCT detected it in 38.5% of eyes operated on by trainees [53], whereas clinically based series reported lower rates; intravitreal triamcinolone prophylaxis reduced CME in eyes with pseudoexfoliation [46]. Clinically relevant hypotony occurred in about 7% of eyes, although statistical hypotony (IOP < 6.5 mmHg) was recorded in 27% of eyes in the largest series [65], so definitions matter. Suture-related complications were uncommon overall but reached

40% in one prospective PTFE series in which knots were not buried [36], consistent with reports that unburied PTFE knots predispose to erosion; burying or rotating the knots is therefore recommended.

Our findings are consistent with a meta-analysis that found similar long-term visual outcomes and complication rates for sutured scleral fixation and the Yamane technique, with faster surgery for Yamane [10]. Choice between techniques should therefore consider IOL availability, surgeon experience, the need for vitrectomy, and patient factors such as young age or prior dislocation, for which the stability of four-point fixation may be advantageous [28].

Limitations

This review has several limitations. First, most included studies were single-arm, retrospective case series at moderate risk of bias; pooled estimates describe outcomes after the procedure rather than effects relative to an alternative. Second, the SD of change had to be derived under an assumed correlation, although results were insensitive to this assumption. Third, follow-up duration, definitions of complications (for example, the IOP thresholds for ocular hypertension and hypotony, or the method of CME detection) and outcome reporting varied, and not every study reported every complication; a complication was counted as absent only when its absence was stated. Fourth, three included cohorts (Nofal 2018, Laham 2017 and Zukerman 2023) were available only as conference abstracts and contributed only to complication-specific analyses for which data were extractable. Their classification as separate cohorts was based on the available report-level information and absence of identified evidence of overlap; the limited methodological detail in abstracts means that cohort independence and outcome ascertainment cannot be verified as fully as for full-text articles. Fifth, several Gore-Tex series could not be included because the IOL model or fixation configuration was not reported or two- and four-point fixation were mixed, and overlap between cohorts from the same centre cannot be fully excluded [24, 33, 55, 72, 73]. Sixth, for one large series some reported values were internally inconsistent [47], although excluding it did not change the conclusions. Finally, no protocol was registered in advance; the review was registered retrospectively and methodological decisions were finalized during the review process. Certainty of evidence was rated very low across all assessed outcomes.

Conclusions

Four-point scleral fixation of posterior chamber IOLs was associated with improved visual acuity and a low incidence of serious postoperative complications, including retinal detachment, IOL dislocation and endophthalmitis. Ocular hypertension and cystoid macular oedema were among the most frequently reported complications, highlighting the importance of postoperative monitoring. However, the very low certainty of the available evidence limits the strength of these conclusions. Further prospective comparative studies with standardized outcome definitions and long-term follow-up are warranted to better define the efficacy and safety of four-point fixation relative to alternative IOL fixation techniques.

Abbreviations

BCVA
best-corrected visual acuity
CI
confidence interval
CME
cystoid macular oedema
GLMM
generalized linear mixed model
GRADE
Grading of Recommendations Assessment, Development and Evaluation
IOL
intraocular lens
IOP

intraocular pressure
logMAR
logarithm of the minimum angle of resolution
NOS
Newcastle-Ottawa Scale
PPV
pars plana vitrectomy
PRISMA
Preferred Reporting Items for Systematic reviews and Meta-Analyses
PTFE
polytetrafluoroethylene
RoB 2
Cochrane risk-of-bias tool for randomized trials
UDVA
uncorrected distance visual acuity.

Declarations

Ethics approval and consent to participate:

Not applicable. This study is a systematic review of published data.

Consent for publication:

Not applicable.

Competing interests:

The authors declare that they have no competing interests.

Funding:

This research received no external funding.

Authors' contributions:

JDS: conceptualization, methodology, literature search, study selection, data extraction, risk-of-bias and certainty assessment, writing – original draft. AD: study selection, verification of extracted data, statistical analysis. RR: resolution of disagreements in study selection, supervision, writing – review and editing. All authors read and approved the final manuscript.

Acknowledgements:

Not applicable.

Availability of data and materials:

The extracted dataset, R analysis script, screening log and risk-of-bias assessments are provided as Additional files 2–4 and are available on the Open Science Framework (registration doi:10.17605/OSF.IO/DTY7X).

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Figures

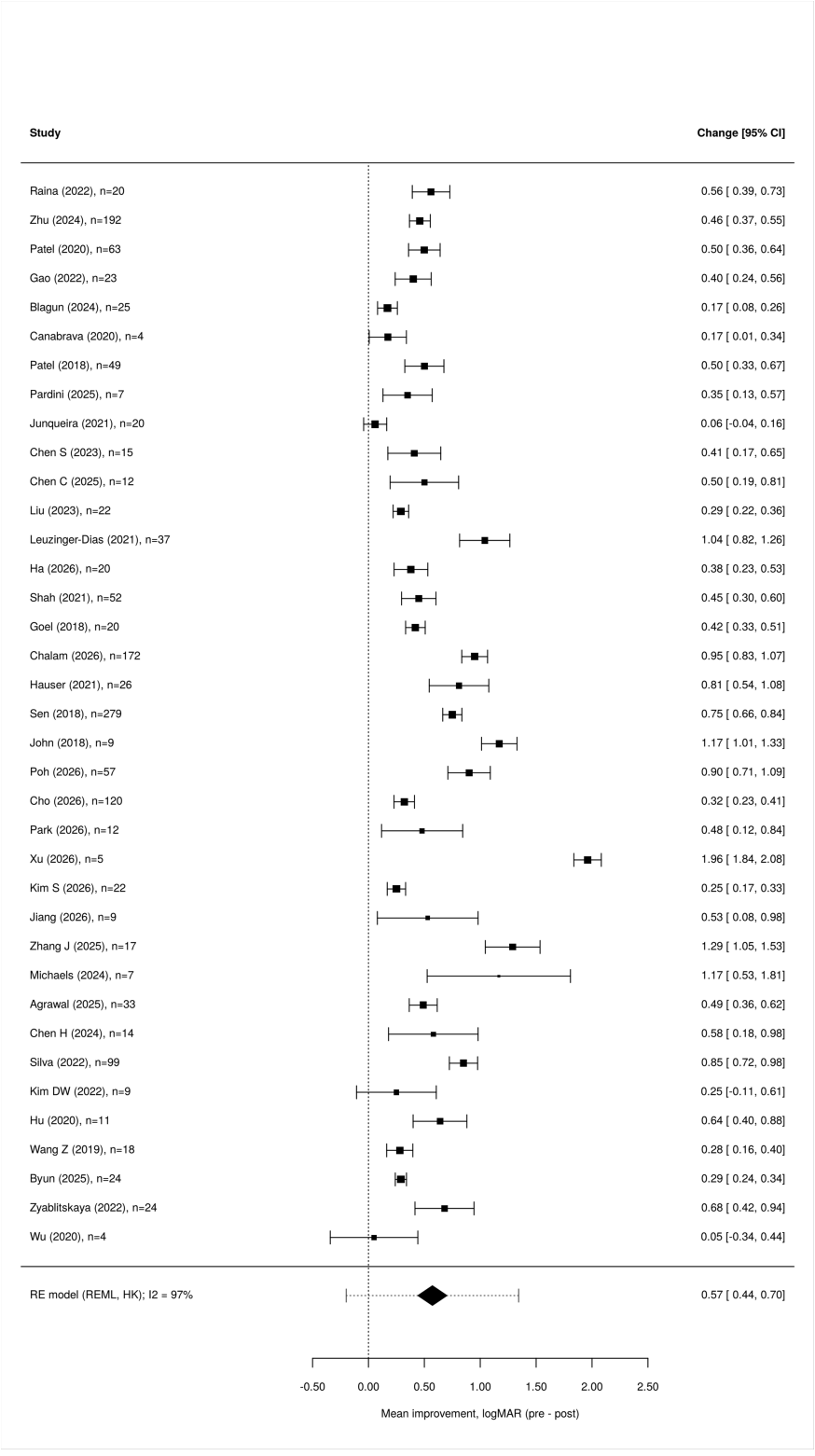


Figure 1

PRISMA 2020 flow diagram of study selection.

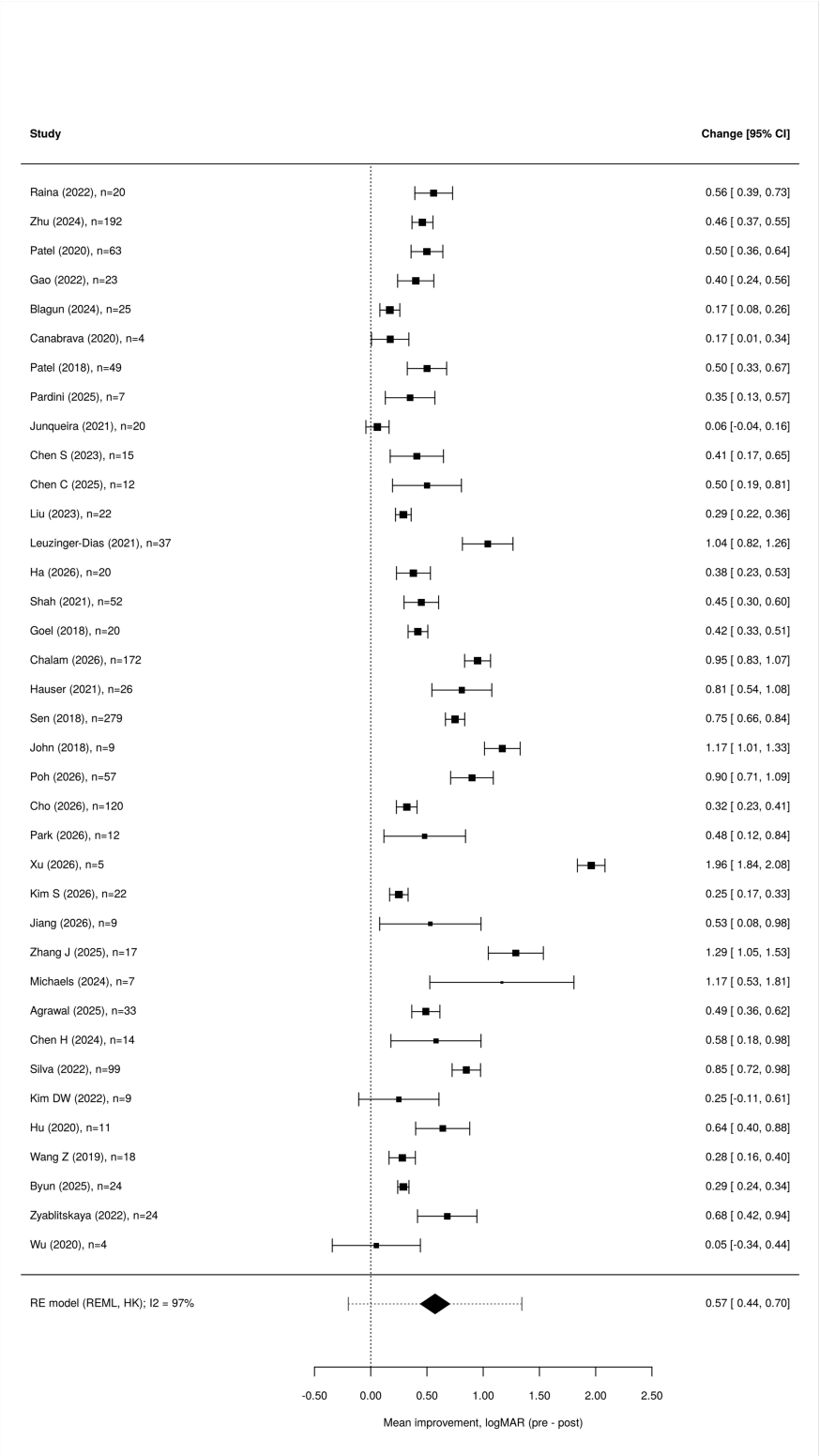


Figure 2

Forest plot of the within-study change in best-corrected visual acuity (preoperative minus postoperative logMAR; positive values indicate improvement). Random-effects model (REML, Hartung-Knapp); dashed line shows the 95% prediction interval.

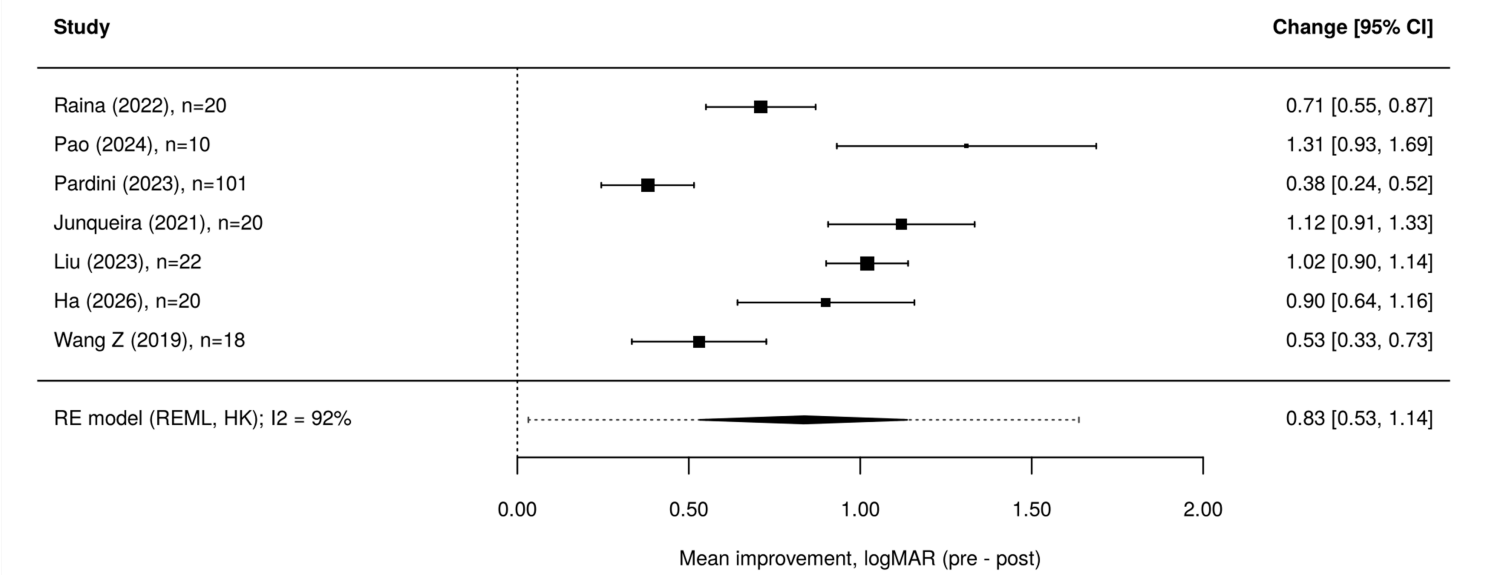


Figure 3

Forest plot of the within-study change in uncorrected distance visual acuity (logMAR).

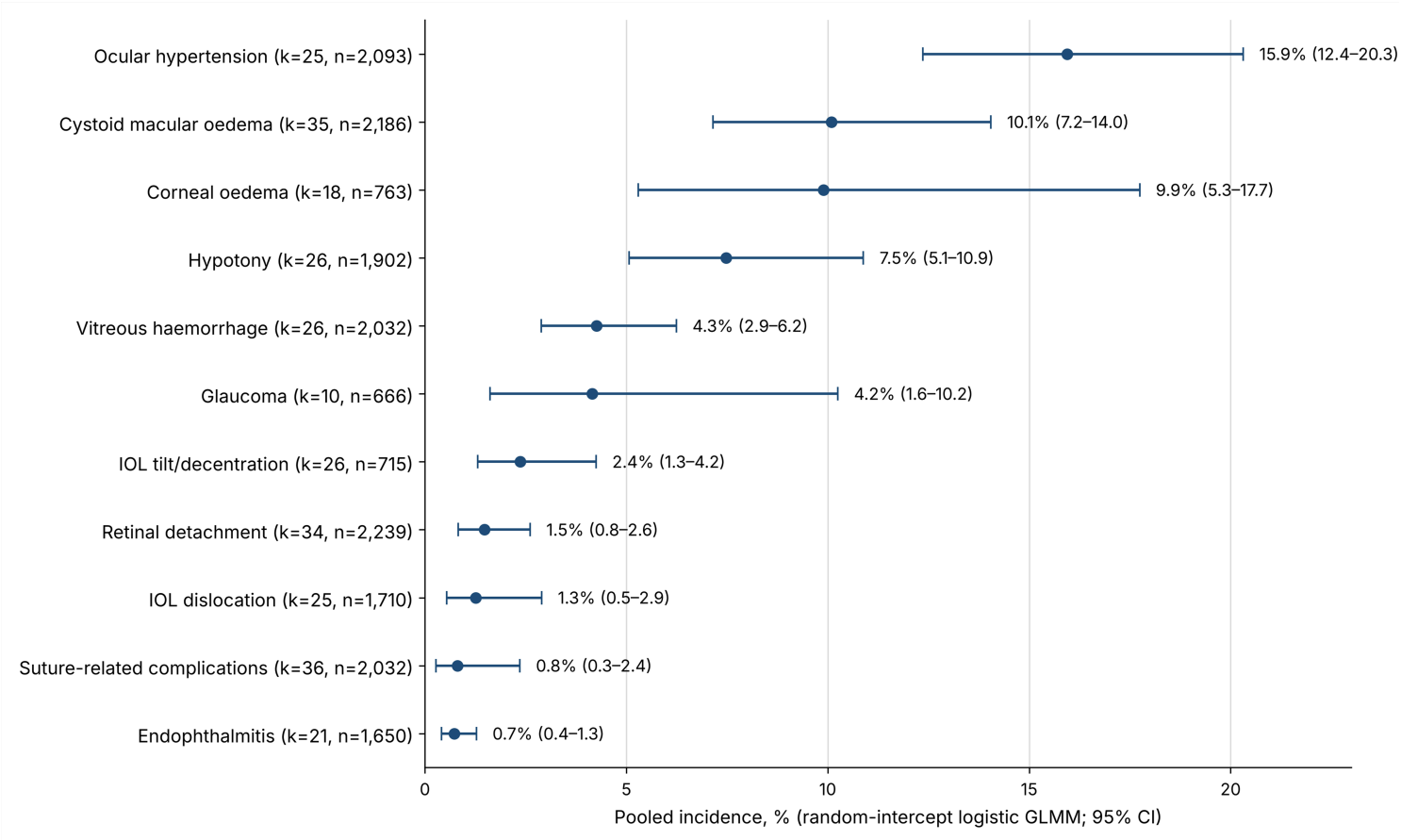


Figure 4

Pooled incidence of postoperative complications after four-point scleral IOL fixation (random-intercept logistic GLMM). k, number of studies.