

Should multifocal lenses be avoided in patients with concurrent pathology affecting the retina? A systematic review

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Abstract

Purpose

It is common for cataract surgeons to avoid implanting multifocal intraocular lenses (MIOLs) during cataract surgery in patients with concurrent retinal pathology, primarily for fear of poorer postoperative visual outcomes compared with monofocal lenses. However, there has been little literature seeking to affirm or challenge this practice. Thus, this systematic review aims to evaluate the visual outcomes of MIOL use in patients with concurrent retinal pathology to date.

Methods

This systematic review complied with PRISMA2022 reporting guidelines and was prospectively registered on PROSPERO (CRD42025646744). We identified articles describing MIOL implantation during cataract surgery in patients with coexisting retinal pathology by systematically searching PubMed, Medline, EMBASE and SCOPUS, on June 7th, 2025.

Results

We identified 2031 papers in the initial search. After screening 981 papers, 11 were included for review. Visual outcomes after trifocal IOL implantation in 520 eyes with concurrent retinal pathologies were similar to those achieved in comparator lenses, albeit with more variability when retinal disease was more advanced. Contrast sensitivity with MIOLs was more significantly reduced in patients with more advanced retinal disease staging for dry age-related macular degeneration, epiretinal membrane and manifest but not preperimetric glaucoma.

Conclusion

The findings of this systematic review suggest multifocal IOLs have led to acceptable postoperative visual outcomes in some patients with early, but not more advanced retinal disease including glaucoma at the time of cataract surgery. Insufficient data exists to guide when to strictly advise against MIOLs. However, preliminary evidence suggests visual and functional outcomes to be inferior in eyes with advanced retinal disease and manifest glaucoma, which may discourage MIOLs in eyes with even early-stage disease given the risk of disease progression.

Introduction

Presbyopia, a universal and inevitable consequence of aging, impairs the ability to focus on nearby objects due to the loss of lens accommodation. In the elderly population undergoing cataract surgery, addressing presbyopia simultaneously presents an opportunity to grant spectacle independence. Traditionally, monofocal intraocular lenses (IOLs) have been the mainstay, correcting only one focal point and leaving patients dependent on spectacles for near or distance vision. However, multifocal IOLs provide a higher degree of spectacle independence, offering significant improvements in quality of life.

Multifocal IOLs (MIOLs) function to provide spectacle independence in presbyopic eyes through splitting light rays to different focal points, with bifocal and trifocal IOLs splitting light into two and three focal points respectively (Alio et al., 2017). However, despite this benefit, the use of trifocal IOLs in patients with concurrent ocular pathologies such as macular degeneration, diabetic retinopathy, or epiretinal membrane is often discouraged. This reluctance stems from concerns about reduced visual acuity and impaired contrast sensitivity (Alio et al., 2017), causing many patients to be denied access to this technology based on hypothetical outcomes (Grzybowski et al., 2020). While there have been suggestions that extended depth of focus IOLs better preserve contrast sensitivity and visual acuity than trifocals (Reinhard et al., 2021), the quality of vision is still considered inferior to that achieved with monofocal lens implantation.

This systematic review aims to determine whether sufficient evidence exists to support or discourage the use of MIOLs in patients with retinal pathology, based on visual acuity, contrast sensitivity and whether the MIOL interferes with retinal imaging for monitoring concurrent retinal pathologies. The current limited evidence on this topic has not yet been evaluated, realising a need for synthesised clinical data to support or challenge the commonly held existing precautions against MIOL implantation in patients with concurrent retinal pathology (Montés-Micó et al., 2004, Cao et al., 2019). Importantly, the possible finding that changes in contrast sensitivity or visual acuity are not clinically significant in early disease could change how ophthalmologists guide patients towards lens selection, possibly expanding the cohort among which multifocal may be offered. This would represent a paradigm shift, enhancing visual outcomes and quality of life for patients with co-existing ocular pathologies (Schein et al., 1995).

Material and Methods

Database and search strategy

This study was prospectively registered on the PROSPERO database (CRD42025646744) and conducted in accordance with the PRISMA2020 reporting guidelines (Page et al., 2021). On the 7th of June 2025, a literature search was conducted on the following databases: PubMed, Medline, EMBASE and SCOPUS. We identified articles describing use of multifocal lenses for cataract surgery in those with macular and other retinal pathology by searching the key words: ((trifocal) OR (bifocal) OR (multifocal)) AND (cataract) AND (lens) AND ((macular) OR (retina) OR (retinal) OR (macula) OR (epiretinal membrane) OR (glaucoma)). English translations of non-English abstracts and unpublished studies were sought where available and applicable. Further studies were acquired by examining the reference lists of included studies. Additional studies were located through hand searching and content area expert contributions.

Our primary outcome measure was visual acuity. We also analysed contrast sensitivity outcomes, interference with retinal imaging, and other outcomes reported by each study.

Eligibility criteria and data extraction

Covidence (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia. Available at www.covidence.org) was employed to screen studies for eligibility. Two reviewers (AM & NP) were selected to independently review each study according to the inclusion and exclusion criteria. A third reviewer (SZ) resolved any conflicts. Studies were included if they described the use of multifocal intraocular lenses in patients with concurrent retinal pathology. Studies were excluded if full texts or English translations were not available, and if they were editorials or letters. There was no restriction on publication date. We extracted the study design, dataset characteristics, type of multifocal lens used, the presence of a comparator group, follow-up characteristics, and primary and secondary outcomes from each included study. Cochrane's collaboration tool for randomized controlled trials and the Newcastle-Ottawa checklist in observational studies was employed for risk of bias assessment.

Ethics

Ethics approval was not sought as this report does not contribute any new data on human or animal subjects.

Results

Characteristics of studies included in review

Our search returned 2013 studies. 1032 studies were initially identified as duplicates and removed from the review. 981 abstracts were screened, and 42 full-text studies were assessed for eligibility. 11 studies were included in the review. In all 11 studies, the outcomes of bifocal or trifocal lens implantation in eyes with comorbid ocular pathology affecting the retina at the time of cataract surgery were evaluated, including epiretinal membrane and glaucoma. The nature of the search and heterogeneity of the identified trials, which each used different lenses in different cohorts, failed to justify meta-analytic pooling of outcomes.

Outcome Comparisons:

Although eleven studies met inclusion criteria for this systematic review, few others were identified as discussing the theoretical merits and detractors of MIOL implantation in those with concurrent retinal pathology (Sánchez-Sánchez et al., 2021b, Werner et al., 2015, Ahad et al., 2014). Naturally, these discursive papers did not meet the inclusion criteria for this review and were thus excluded. Most of the ten included studies evaluated the use of MIOL's in those with concurrent retinal pathology at the time of cataract surgery against monofocal comparator lenses, while few evaluated outcomes of MIOL implantation retrospectively without comparators. Studies were critically evaluated into three categories to guide future research: those assessing visual outcomes, contrast sensitivity, and the impact of MIOLs on retinal imaging for disease monitoring post-implantation.

Table 1
Characteristics of studies included in review

First Author (Year), Region	Study design	Dataset characteristics	Type of Multifocal Intraocular lens (MIOL)	Comparator group	Follow-up	Primary outcomes	Secondary outcomes
Kamath (2000) United Kingdom(Kamath et al., 2000b)	Prospective Cohort Study	133 eyes (111 patients) with cataract and one or more concurrent eye disease 81 eyes (70 patients) received Array multifocal IOL. 52 eyes (41 patients) received a AMO SI-40NB	Array Multifocal IOL	Monofocal IOL (AMO SI-40NB)	Mean follow-up time of 4 months	Snellen uncorrected and best corrected distance visual acuity	Snellen uncorrected and best corrected near visual acuities, near visual acuity with distance correction
Gayton (2012) USA(Gayton et al., 2012)	Case Series Study	20 eyes (13 patients, aged > 50) with cataracts and age-related macular degeneration	Acrysof Restor SN60D3 Multifocal IOL	None	6 months	Near and distance best visual acuity	Uncorrected visual acuity, Visual function questionnaire
Ouchi (2015)(Ouchi and Kinoshita, 2015)	Case Series Study	15 eyes (cataract with coexisting ocular pathologies: 6 high myopia, 2 fundus albipunctatus, 2 branch RVO, 4 glaucoma, 2 keratoconus)	Lentis Mplus refractive bifocal multifocal IOL	None	6 months	Uncorrected/corrected distance and near VA (UDVA, CDVA, UNVA, CNVA)	Contrast sensitivity, defocus curve, patient-reported visual quality
Patel (2019)(Patel et al., 2019)	Retrospective Case Series Study	6 eyes (combined phacoemulsification + PPV for idiopathic ERM)	Alcon AcrySof IQ ReSTOR SN6AD1 (Apodized diffractive bifocal MIOL) bifocal	None	6–12 months	Uncorrected and corrected near and distance visual acuity	Central Macular thickness, IOP, ELM/ISOS integrity
Borkenstein (2020), Austria(Borkenstein and Borkenstein, 2020)	Case series	11 patients who had dry AMD with geographic atrophy that was stable for > 3 months on OCT underwent high-add IOL	LENTIS® MAX LS-313 MF 80	None	4 years	Autonomy and quality of life of patients with advanced dry AMD	Visual acuity, posterior capsule opacification (PCO), conversion of dry AMD to wet disease and the impact of the high-add IOLs on the feasibility of funduscopy and quality of OCT examinations
Auffarth (2021) (Auffarth et al., 2021)	Multicenter open-label pilot study	20 eyes of 20 patients with late inactive AMD	LS-313 MF80 segmented refractive bifocal IOL (+ 8.0 D add)	None	12 months	Distance-corrected near VA (DCNVA)	CDVA, UDVA, UNVA, reading performance, patient satisfaction
Freissinger (2021) Germany(Freissinger et al., 2021a)	Case control Study	52 eyes (48 patients): 42 eyes in the retrospective-matched case-control group (21 multifocal IOLs and 21 matched eyes with monofocal IOLs) all post-retinal detachment repair. An additional 24 eyes of the 20 patients receiving multifocal IOLs were prospectively assessed after	AT LISA tri IOL, AcrySof SN6D1 Restor + 3.0 D IOL, Tecnis Symphony IOL, 1stQ Basis Z trifocal IOL	Monofocal IOL	6 weeks retrospectively and 12 months prospectively	Retrospective cohort: Corrected distance visual acuity (CDVA) after 6 weeks and 12 months. Prospective, post-retinal detachment repair multifocal IOL cohort at 1 year: uncorrected visual acuity (UCVA), uncorrected intermediate visual acuity (UIVA), uncorrected near visual acuity (UNVA) in	Not mentioned.

First Author (Year), Region	Study design	Dataset characteristics	Type of Multifocal Intraocular lens (MIOL)	Comparator group	Follow-up	Primary outcomes	Secondary outcomes
		retinal detachment repair.				multifocal IOL eyes.	
Kim (2021)(Kim et al., 2021)	Retrospective cohort study	91 eyes with mild non-foveal involving ERM post-PanOptix TFNT IOL implantation vs 83 age-matched eyes without ERM (all with same MIOL type)	PanOptix TFNT trifocal IOL (Alcon, USA)	Age-matched controls with MIOL but no ERM	6 months	Visual acuity: UDVA, CDVA, UNVA	Contrast sensitivity, higher-order aberrations, area ratio, Strehl ratio, macular thickness, ERM grade subanalysis
Sánchez-Sánchez (2021) Spain(Sánchez-Sánchez et al., 2021b)	Prospective observational cohort study	90 eyes (38 patients) undergoing bilateral cataract surgery with IOL implantation, comparing monofocal, diffractive trifocal and extended depth of focus intraocular lenses.	AcrySof Panoptix and Physiol FineVision.	AcrySof ReSTOR + 3.00 (bifocal) and Technis Symphony (extended depth of focus) IOLs	3 months postoperatively	Visual acuity (distance, intermediate, near); defocus curve	Patient satisfaction, spectacle independence, photic phenomena
Kim (2022)(Kim and Jeon, 2022)	Retrospective review	49 eyes (MIOL-implanted; 25 with stage 2/3 ERM, 24 age-matched controls)	Diffractive-type MIOLs (mix of models)	Age-matched controls (MIOL without ERM)	12 months	Monocular uncorrected distance and near VA (UDVA, UNVA) by ERM stage	Corrected distance VA (CDVA)
Kitnarong (2023), Thailand(Kitnarong and Dagvadorj, 2023)	Prospective cohort study	33 eyes from 26 patients with PAC or PACG and cataract; 14 eyes received diffractive MIOLs, 19 eyes received aspheric MIOLs	Diffractive multifocal IOL (MIOL)	Aspheric monofocal IOL (MIOL)	2–6 months	Contrast sensitivity (CS) at 5 spatial frequencies	Best-corrected distance visual acuity (BCVA), intraocular pressure (IOP), anterior chamber depth (ACD)

Table 2
Results of studies included in review

First Author (Year), Region	Visual acuity outcomes	Contrast sensitivity outcomes	Interference with retinal imaging	Other findings
Kamath (2000), United Kingdom(Kamath et al., 2000b)	55 eyes (67.9%) in the Array multifocal IOL group and 37 (71.2%) in the control group received a BCVA of 6/12 and N8 or better for distance and near ($p > 0.999$; 95% CI -0.152 to 0.172).	Not assessed.	In the multifocal IOL groups, the ability to visualise the retina was not impaired.	Uncorrected visual acuities of 6/12 (distance) and N8 (near) or better were achieved in 11 eyes (13.6%) which received the Array Multifocal Intraocular lens, and 2 eyes (3.8%) in the control group ($p = 0.047$; 95% confidence interval [CI] -0.001 to 0.196).
Gayton (2012), USA(Gayton et al., 2012)	After trifocal IOL implantation, corrected near visual acuity (CNVA) improved in 17 eyes (85%), was unchanged in 1 eye (5%) and decreased in 2 eyes (10%). Corrected distance visual acuity (CDVA) improved in the majority of eyes ($n = 14$, 70%), was unchanged in 4 eyes (20%) and decreased in 2 eyes (10%; loss of 1 and 2 lines respectively)	Not assessed	Not assessed.	Following multifocal IOL implantation, uncorrected near visual acuity (UNVA) improved in 18 eyes (90%), unchanged in 2 eyes. Uncorrected distance visual acuity (UDVA) improved in 4 eyes (20%), was unchanged in 8 eyes (40%) and decreased in 8 eyes (40%). The VFQ-25 questionnaire showed mean improvements in 11 vision-related items, but not in overall general health.
Ouchi (2015), Japan(Ouchi and Kinoshita, 2015)	UDVA and CDVA of 20/20 or better in 87%; UNVA J1 or better in 73%	Contrast sensitivity within normal range across all spatial frequencies	Not specifically discussed; no reported issues	~ 20% of eyes needed near correction; high patient satisfaction; defocus curves showed functional range
Patel (2019), USA(Patel et al., 2019)	CDVA improved from 0.41 ± 0.19 to 0.11 ± 0.08 logMAR; all eyes achieved UNVA of J2 or better	Not assessed.	SD-OCT feasible post-op in all cases; no lens-related interference mentioned	Mild posterior capsule opacification (PCO) in 2 eyes; delayed visual recovery in some; no IOL explants
Borkenstein (2020), Austria(Borkenstein and Borkenstein, 2020)	CDVA remained stable in all patients except the 2 who progressed to wet AMD. At 3 months, uncorrected distance and near visual acuity exceeded preoperative CDVA and BCNVA, respectively, in all patients. Uncorrected near visual acuity remained stable during follow-up in all patients, except in one patient who developed wet AMD.	Not assessed	Cataract removal improved posterior segment visualization.	All patients had functional improvement by 3 months and this was stable or further improved at 6 months. By 48 months, all patients improved from baseline, although decreased from the 6-month value in 6 patients, including the 2 patients who progressed to wet AMD. Quality of life at 3 months was improved in 10 out of 11 patients. At 48 months, improvements were seen in 9 out of 11 patients.
Auffarth (2021), Germany(Auffarth et al., 2021)	DCNVA improved significantly from $0.95 (\pm 0.19)$ to $0.74 (\pm 0.35)$ logMAR, until 6 months after surgery, $P < 0.05$; 50% gained ≥ 5 lines, 30% gained ≥ 7 lines. CDVA improved from $0.70 (\pm 0.23)$ to $0.59 (\pm 0.30)$ logMAR, UDVA from $0.94 (\pm 0.25)$ to $0.69 (\pm 0.34)$ logMAR, UNVA from $1.08 (\pm 0.19)$ to $0.87 (\pm 0.43)$ logMAR.	Not assessed	Retinal imaging not described in detail; no reported issues.	95% patient satisfaction; improved reading ease; 70% reported spectacle independence
Freissinger (2021), Germany(Freissinger et al., 2021a)	In the retrospective MFIOL group, mean preoperative CDVA was 1.16 ± 1.2 logMAR, and improved to 0.20 ± 0.36 logMAR ($p = .001$) at 12 months post-operatively. In the Prospective MFIOL group, mean UDVA at 12 months post-operatively was 0.21 ± 0.34 logMAR, UIVA was 0.17 ± 0.28 logMAR, and UNVA was 0.23 ± 0.32 logMAR	Not assessed.	Macular optical coherence tomography (OCT) performed in all eyes postoperatively to exclude postoperative macular oedema or any trapped subretinal fluid. No optical distortions reported.	High patient satisfaction in the 20 patients surveyed post-operatively in the prospective cohort. 2 patients reported glare and contrast vision deficiency; colour vision deficiency, and halos were reported by 1 patient each. No lens exchange; most achieved spectacle independence.
Kim (2021), South Korea(Kim et al., 2021)	No significant difference in UDVA, CDVA, or UNVA between ERM and control groups at 6 months. Visual	ERM group had significantly lower contrast sensitivity at 4.0° , 2.5° , 1.0° , 0.64°	No issues reported with SD-OCT imaging; ERM grading was feasible	Area ratio significantly lower in ERM group (45.13 vs 50.34, $p = .044$); Strehl ratio trend lower in ERM but not statistically

First Author (Year), Region	Visual acuity outcomes	Contrast sensitivity outcomes	Interference with retinal imaging	Other findings
	acuity improved in both groups over time. Grade 2 ERM group had worse CDVA than grade 1 at 6 months	(scotopic) and 4.0°, 1.0°, 0.64° (photopic); multivariate regression showed ERM independently predicted reduced contrast		significant; no metamorphopsia or macropsia reported
Sánchez-Sánchez (2021), Spain(Sánchez-Sánchez et al., 2021b)	Control subjects displayed better monocular BCVA, UDVA, CDVA and LCVA than patients with both dry AMD and glaucoma, and also had better binocular acuity in the defocus curve (between - 2.00 D and + 0.50 D). The difference between control and those with preperimetric glaucoma was not significant.	Patients with dry AMD had poorer contrast sensitivity at low spatial frequencies (e.g., 3 cycles per degree), while those with glaucoma showed deficits at higher frequencies (e.g., 12 cpd).	Although not the primary outcome, the study did not report any direct interference with retinal imaging or monitoring.	Patients with glaucoma and dry AMD required more near spectacle correction. Subjective symptoms differed: healthy and preperimetric glaucoma patients reported more halos, whereas glaucomatous and AMD eyes experienced more glare and night-driving difficulties.
Kim (2022), S. Korea(Kim and Jeon, 2022)	CDVA improved in ERM eyes: Stage 2 (0.25→0.10), Stage 3 (0.33→0.18 logMAR); UNVA J2 or better in 92% (Stage 2)	Not assessed directly.	SD-OCT usable postoperatively in all eyes; ERM grading feasible	1 eye required ERM reoperation; delayed visual recovery in 3 eyes; no IOL explants
Kitnarong (2021), Thailand(Kitnarong and Dagvadorj, 2023)	Significant improvement in BCVA postoperatively in both multifocal and monodical IOL groups with no significant difference between groups	Postoperative contrast sensitivity was not significantly different between multifocal and monofocal IOL groups. Contrast sensitivity improved significantly at all spatial frequencies in both groups ($p < 0.001$). Mean postoperative CS at 1.5, 3.0, 6.0, 12.0, and 18.0 CPD: MIOL group – 28.03, 42.63, 44.84, 10.82, 2.86; mIOL group – 29.55, 49.63, 46.20, 16.83, 7.09.	Not reported.	There was a significant decrease in intraocular pressure ($p = 0.001$) and increase in anterior chamber depth ($p < 0.001$) in both groups; no adverse events reported.

Visual Outcomes of MIOL implantation with co-existing pathology affecting the retina:

All 11 studies included for review assessed visual outcomes of MIOL implantation in eyes with co-existing pathology affecting the retina. Most of the included studies demonstrated visual outcomes to improve following MIOL implantation.

Several case series, including those by Gayton et al. (2012) ($n = 20$ eyes), Ouchi et al. (2015) ($n = 15$ eyes), Patel et al. 2019, and Borkenstein et al. (2020) ($n = 11$ eyes) reported improvements in visual outcomes following MIOL implantation in patients with co existing retinal pathology at the time of cataract surgery. In Gayton et al. (2012) case series, DCNVA at 33cm improved in 17 eyes (85%), was unchanged in 1 eye (5%) and decreased in 2 eyes (10%), at the 6-month follow-up time post insertion of a Acrysof Restor SN60D3 multi-focal IOL. In Ouchi et al (2015)'s study, UDVA and CDVA of 20/20 or better was appreciated in 87% of eyes, and a UNVA J1 or better was reported in 73% of eyes at six-month follow-up. In Patel et al. 2019's retrospective case series, CDVA improved from 0.41 +/- 19 to 0.11 +/- 0.08 LogMAR, with all eyes achieving a UNVA of J2 or better at a follow-up period of 6–12 months. Borkenstein et al (2020)'s case study concluded that CDVA remained stable in all patients except those who developed wet AMD ($n = 2$). However, at 3-month follow-up, both CDVA and CNVA improved from pre-operative baseline in all patients, irrespective of whether their AMD had remained stable or progressed to the wet sub-type.

Two included studies are retrospective cohort studies. Kim et al. (2021) compared visual acuity outcomes between those receiving a PanOptix TFNT trifocal IOL in the presence of an epiretinal membrane (ERM) and aged-matched controls with MIOL implantation but no ERM. They concluded that there was no significant difference in UDVA, CDVA, or UNVA between ERM and control groups at 6 months. However, visual acuity improved in both groups over time. Similarly, Kim et al. (2022)'s retrospective review analysed visual outcomes of 49 eyes receiving a diffractive-type MIOLs. They compared 25 eyes with stage 2/3 ERM, with 24 aged-matched controls. Kim et al. (2022) concluded that CDVA improved in ERM eyes, with a score of UNVA J2 or better in 92% of eyes.

Freissinger et al. (2021) is a case-control study in which visual outcomes were compared after retinal detachment repair in 21 eyes in each group implanted with either mono-focal or multifocal IOLs. CDVA improved significantly in both groups. In the mono-focal group at 6 weeks postoperatively, the mean preoperative CDVA had significantly improved from a baseline of 1.35 ± 1.38 logMAR to 0.29 ± 0.37 logMAR ($p = 0.001$) and remained stable at 12 months prospectively (0.29 ± 0.37 logMAR) ($p = 0.001$ compared to baseline). In the multifocal group, the mean preoperative CDVA improved significantly from 1.16 ± 1.2 logMAR to 0.37 ± 0.29 logMAR at 6 weeks ($p = 0.003$) and further to 0.20 ± 0.36 logMAR at the 1-year timepoint ($p = 0.001$ compared to baseline).

Three prospective cohort studies are included in this review. Kamath et al. (2000) aimed to evaluate whether outcomes of distance vision with the Array Multifocal lens are comparable to that of a monofocal lens across 133 eyes from 111 patients with cataracts and co-existing ocular conditions. Kamath et al. (2000) reported that 55 eyes in the Array multifocal IOL group (67.9%) and 37 (71.2%) in the control group received a BCVA of 6/12 and N8 or better for

distance and near group ($p > 0.999$; 95% CI -0.152 to 0.172). However, a statistically significant difference in visual acuity was reported when testing DCVA with distance corrected vision, as 40 eyes (49.4%) which received the Array multifocal intraocular lens and 4 eyes (7.7%) in the control group reported a DCVA of 6/12 and N8 or better with distance correction ($p < 0.0001$; 95% CI 0.274 to 0.539), demonstrative of improved glasses independence with the multifocal lenses. Sanchez-Sanchez et al (2021)'s prospective study included 90 eyes of 45 patients undergoing bilateral cataract surgery, comparing diffractive monofocal, trifocal and extended depth of focus (EDOF) intraocular lenses. They concluded that control subjects displayed better BCVA, UDVA, CDVA and LCVA than patients with both dry AMD and glaucoma following cataract surgery. Kitnarong et al (2023)'s aimed to compare the efficacy of diffractive multifocal IOL and aspheric monofocal IOL. They found significant improvement in BCVA postoperatively in both multifocal and monodical IOL groups, with no significant difference among the two groups.

Only one study is a multi-centre open-label pilot study (Auffart et al. (2021)). Researchers implanted 20 eyes of patients with late inactive AMD with the LS-313 MF80 segmented refractive bifocal IOL (+ 8 D add). They concluded that DCNVA improved significantly from 0.95 (+/- 0.19) to 0.74 (+/- 0.35) LogMAR until 6 months post surgery ($p < 0.05$).

Contrast Sensitivity Outcomes:

Four of the included studies reported outcomes relating to contrast sensitivity. A retrospective study by Kim et al. (2021) found that the ERM group was associated with lower contrast sensitivity at 4.0°, 2.5°, 1.0°, 0.64° (scotopic) and 4.0°, 1.0°, 0.64° (photopic) (Kim et al., 2021). In addition, their multivariate regression analysis showed the ERM independently predicted reduced contrast sensitivity. A case series by Ouchi et al. (2015) reported that contrast sensitivity was within normal range across all spatial frequencies after MIOL implantation in eyes with retinal pathology co-existing at the time of surgery (Ouchi and Kinoshita, 2015). Sanchez-Sanchez et al (2021) also evaluated the effects of multifocal lens implantation on contrast sensitivity in eyes with concurrent retinal pathology, drawing comparison with bifocal and extended depth of focus IOLs (Sánchez-Sánchez et al., 2021b). Sanchez-Sanchez reported measured binocular contrast sensitivity across four spatial frequencies (3, 6, 12, and 18 cycles per degree [cpd]) in healthy controls, patients with glaucoma, preperimetric glaucoma, and dry age-related macular degeneration. At 3 cpd, contrast sensitivity was significantly lower in the dry AMD group (1.88) compared to healthy controls (2.08; $P = 0.008$). At 12 cpd, patients with glaucoma exhibited significantly reduced contrast sensitivity (1.28) relative to healthy subjects (1.65; $P = 0.016$). While mean values at 6 and 18 cpd also trended lower in the glaucoma and dry AMD groups, these differences did not reach statistical significance ($P = 0.085$ and $P = 0.095$, respectively). Patients with preperimetric glaucoma, which is not strictly a retina-involving pathology, demonstrated contrast sensitivity values closely approximating those of the control group across all spatial frequencies. In their prospective cohort study, Kitnarong et al. (2023) also reported contrast sensitivity outcomes (Kitnarong and Dagvadorj, 2023). They concluded that post-operative contrast sensitivity was not significantly different between the multifocal and monofocal IOL groups. Moreover, they found that contrast sensitivity significantly improved at all spatial frequencies in both groups ($p < 0.001$).

The influence of Multifocal IOLs on Retinal Visualisation:

7 studies included in this review reported the impact of multifocal IOLs on retinal visualisation and retinal imaging. In all 7 studies, the presence of a multifocal IOL either had no impact on retinal visualisation, or improved visualisation of the retina. In Kamath et al. (2000)'s study, the ability to visualise the retina was not impaired in multi-focal IOL groups (Kamath et al., 2000a). In Patel et al.'s (2019) case series, SD-OCT remained feasible post-op in all cases and no impact on lens-related interference was reported (Patel et al., 2019). Similarly, Freissinger et al. (2021) performed macular OCT imaging in all eyes post multifocal IOL implantation to rule out a postoperative macular oedema or any subretinal fluid (Freissinger et al., 2021b). There were no optical distortions reported following insertion of the multifocal IOL lens. Similarly, there were no issues reported with SD-OCT imaging and ERM grading remained feasible in Kim et al. (2021)'s retrospective study (Kim et al., 2021). Kim et al. (2022) also found that SD-OCT remained usable post-operatively in all eyes (Kim and Jeon, 2022). Sanchez-Sanchez et al. (2021) did not report any direct interference with retinal imaging or monitoring in their prospective observational study (Sánchez-Sánchez et al., 2021a). In Borkenstein et al. (2020)'s case series, cataract removal was found to improve segment visualisation (Borkenstein and Borkenstein, 2020). None of the studies included for review commented on the effect of multifocal IOLs on other vitreoretinal surgical considerations such as the view during vitrectomy.

Discussion

Summary of results

This systematic review aimed to search and appraise all literature reporting the outcomes of multifocal lens implantation in cataract surgery on patients with concurrent pathology affecting the retina. The available data suggest that multifocal IOL implantation in mild or stable retinal disease provides functional gains in visual acuity without resulting in prohibitive losses in contrast sensitivity. In eyes affected by various retinal diseases including age related macular degeneration, glaucoma, maculopathies, epiretinal membrane and repaired retinal detachment, visual outcomes with MIOLs are comparable with those who undergo monofocal lens implantation or healthy controls in early disease stages (Sánchez-Sánchez et al., 2021b).

Age-Related Macular Degeneration (AMD):

Data across four studies suggest that in stable or early non-exudative (or dry) AMD, MIOLs can safely enhance distance and near visual acuity and maintain fundus visualisation, albeit with moderate residual low-frequency contrast sensitivity losses. Auffarth et al. (2021) demonstrated a significant improvement in distance-corrected near visual acuity (DCNVA) at six months in a cohort of eyes with late inactive AMD implanted with a segmented refractive bifocal MIOL. Similar benefits were noted by Gayton et al. (2012), where most patients with dry AMD experienced improved CNVA and UNVA, and in Borkenstein et al. (2020), where visual function improved or remained stable in all AMD patients except those who progressed to wet AMD.

In a research letter responding to Gayton's study, Patsoura et al. (2012) recorded preoperative visual acuity and disease severity in 29 eyes with dry AMD prior to implantation of the Restor + 4.0 D add MIOL (Patsoura and Georgaras, 2012). Patsoura found the implanted multifocal IOL not meaningfully to improve corrected near visual acuity (CNVA) in mild AMD. Contrastingly, patients with moderate to advanced AMD and even those with advanced maculopathy and poor baseline CDVA (20/400 to counting fingers) mostly achieved a two-line improvement in UNVA with stable or improved CDVA (Patsoura and Georgaras, 2012). However, Patsoura et al. noted that these outcomes did not replicate the degree of visual improvement reported by Gayton et al., raising the possibility that underlying AMD severity imposes a ceiling effect on visual gains achievable through multifocal IOLs.

Contrast sensitivity findings with MIOLs in AMD are more equivocal. Sánchez-Sánchez et al. (2021) reports patients with dry AMD to have significantly lower binocular contrast sensitivity at low spatial frequencies (3 cpd) when compared with controls. Although these reductions did not consistently reach statistical significance across all frequencies, they suggest that even stable AMD may impose limitations on contrast function following MIOL implantation. Thus, these data suggest MIOLs may be appropriately considered in early-stage AMD where patients prioritise spectacle independence and where macular integrity is sufficient to maintain photopic function. Moreover, Sánchez-Sánchez et al. suggested that patients with early-stage glaucoma reported better visual outcomes with MIOLs than those with dry MD, suggesting eyes with AMD are likely more sensitive than glaucoma to any detrimental effects on visual acuity from diffractive MIOLs.

Glaucoma

The findings of this systematic review support MIOL implantation to be feasible in eyes with early or well-controlled glaucoma, delivering comparable acuity with selective reductions in high-frequency contrast sensitivity. Kitnarong et al. (2023) observed no significant differences in postoperative BCVA or contrast sensitivity between MIOL and monofocal IOL recipients with primary angle-closure glaucoma. Similarly, Sánchez-Sánchez et al. (2021) reported that eyes with preperimetric glaucoma performed comparably to controls across all spatial frequencies of contrast sensitivity, suggesting that early glaucomatous pathology does not preclude the use of MIOLs (Sánchez-Sánchez et al., 2021b).

However, in eyes with established glaucoma and visual field loss, the penalty in contrast sensitivity from multifocal lens implantation may be more clinically relevant. In Sánchez-Sánchez et al., eyes with advanced glaucoma demonstrated a statistically significant reduction in contrast sensitivity at higher spatial frequencies (12 cpd), with trends towards lower values at other frequencies as compared with monofocal IOLs in the same patient cohort. Given that glaucoma inherently reduces peripheral and contrast vision, the additive effect of MIOL-related contrast degradation may be poorly tolerated in these eyes with advanced disease. Subjectively, patients with manifest glaucoma reported lower satisfaction, a greater reliance on near-vision spectacles, more dysphotophobias and more difficulty with night driving, illustrating qualitative barriers to multifocal lens implantation in eyes with reduced functional reserve from more advanced retinal disease. Thus, these data further suggest that early-stage glaucoma may not limit good postoperative outcomes following multifocal lens implantation. MIOLs would be most advisable in glaucoma in cases where functional fields are intact, and contrast sensitivity remains within acceptable limits.

Epiretinal Membrane:

Data from three studies suggests that MIOLs in eyes with coexisting epiretinal membrane (ERM) can preserve visual acuity with modest losses in contrast sensitivity. Kim et al. (2021) and Kim et al. (2022) each reported that postoperative uncorrected and corrected distance visual acuities in ERM eyes were comparable to those of age-matched controls without ERM. Furthermore, Kim et al. (2022) reported that 92% of ERM eyes attained uncorrected near visual acuity (UNVA) of J2 or better, a result supported by findings from Patel et al. (2019), who demonstrated substantial gains in CDVA alongside consistent postoperative UNVA in a similar cohort.

Despite these favourable acuity outcomes, contrast sensitivity is demonstrably compromised in eyes with greater ERM severity. In Kim et al. (2021), both scotopic and photopic contrast sensitivity were significantly reduced in eyes with mild non-foveal epiretinal membrane compared to controls, and multivariate analysis confirmed ERM as an independent predictor of lower contrast sensitivity. Thus, clinically, while MIOLs may be appropriate in patients with stage 1 or 2 ERM seeking reduced spectacle dependence, those with more advanced membrane changes may experience perceptible contrast-related functional deficits. Clinically, MIOLs could be offered to those seeking spectacle independence with only mild-to-moderate ERM, but patients should be counselled about potential reductions in contrast sensitivity proportional to ERM grade.

Post-Retinal Detachment Repair:

One study suggested that patients with MIOLs achieve ultimately equivalent visual acuity recovery compared to those with multifocal lenses after retinal detachment repair, albeit with a modest delay in early visual recovery. Freissinger et al. (2021) reported that while both MIOL and monofocal cohorts benefited from significant improvements in CDVA post-rhegmatogenous detachment repair, the MIOL group demonstrated a more gradual trajectory of visual improvement, only reaching parity with monofocal comparators after one year. Importantly, there was no impairment of macular imaging or optical coherence tomography (OCT) feasibility, affirming that MIOL optics do not obstruct essential postoperative assessments in these patients. This suggests MIOLs may be reasonably considered in patients with a history of retinal detachment, especially where the urgency of visual recovery is not critical.

Mixed and Other Retinal Diseases:

In eyes with a variety of retinal comorbidities, MIOLs can restore high-quality acuity and improve spectacle independence without significant compromise to contrast sensitivity. Ouchi et al. (2015) reported that 87% of eyes with varied retinal pathology achieved UDVA and CDVA of 20/20 or better, with contrast sensitivity remaining within normal limits. Similarly, Kamath et al. (2000) found no significant difference in BCVA between MIOL and monofocal groups across a cohort with mixed pathologies, while also demonstrating superior spectacle independence in the MIOL group. Patel et al. (2019) further confirmed the feasibility of MIOL use in eyes undergoing concurrent retinal procedures, with no reported optical interference on postoperative imaging.

The findings of this review support the conclusion that selected eyes with stable, non-progressive retinal pathology may still derive satisfactory visual outcomes following implantation of refractive multifocal IOLs despite any potential losses in contrast sensitivity. Sánchez-Sánchez et al. (2021) reported statistically and clinically significant reductions in contrast sensitivity from MIOL implantation in eyes with glaucoma and AMD when compared to healthy controls. Kamath et al. similarly noted lower contrast sensitivity in their multifocal group, albeit noting that these losses were not severe enough to have reduced overall visual satisfaction following MIOL implantation. Additionally, Ouchi (2015) reported contrast sensitivity to remain within normal limits, suggesting that refractive MIOLs may offer improved performance compared to diffractive designs in eyes with concurrent retinal pathology.

Multifocal IOLs have previously been shown to have mixed effects upon contrast sensitivity in eyes without retinal disease. While some studies report reduced contrast sensitivity, particularly in low-light conditions, other studies have found no significant difference compared to monofocal IOLs (Grzybowski et al., 2020). Importantly, contrast sensitivity with multifocal IOLs remains generally within the normal age-matched range, and patients with retinal diseases who receive multifocal IOLs often report improved visual outcomes and satisfaction (Grzybowski et al., 2020). Our study identified that multifocal IOLs either did not influence contrast sensitivity or resulted in worse performance than comparator monofocal or extended depth of focus IOLs. Nevertheless, the multifocal IOLs preserved contrast sensitivity levels within the age-matched normal range (Sánchez-Sánchez et al., 2021b, Gayton et al., 2012). Individuals with a monofocal IOL in one eye and a trifocal IOL in the fellow eye reported greater subjective satisfaction with the trifocal IOL (Gayton et al., 2012). Thus, these data suggest the significant and noticeable benefits of presbyopia correction in patients with stable and early-stage retinal disease to outweigh the less perceptible potential loss of contrast sensitivity, especially in well-lit conditions. As such, subjective visual satisfaction is more likely to improve following diffractive trifocal IOL implantation in those with retinal pathology at the time of surgery.

The influence of Multifocal IOLs on Visualising the Retina:

Across all reports, no study identified meaningful interference with retinal visualization attributable to the presence of a multifocal IOL. Patel (2019) confirmed that spectral-domain OCT (SD-OCT) imaging remained feasible postoperatively in all cases of combined MIOL implantation and ERM peeling. Similarly, Kim (2021) and Kim (2022) both performed detailed macular imaging using SD-OCT, successfully grading ERMs and assessing postoperative retinal structure, indicating no significant imaging interference. Freissinger (2021) and Sánchez-Sánchez (2021) implied routine postoperative monitoring without mentioning difficulty in visualising the retina.

However, the issue of intraoperative and diagnostic visualisation has been raised elsewhere. Importantly, none of the reviewed studies assessed the impact of MIOLs on intraoperative retinal visualisation during vitreoretinal surgery, such as during pars plana vitrectomy. In their discussion, Kim (2021) referenced prior reports (e.g. Yoshino et al. 2010; Hadayer et al. 2017) noting that diffractive multifocal optics may impair the clarity of the surgical field during posterior segment procedures, potentially complicating vitrectomy or laser treatment (Kim et al., 2021). Nonetheless, in practice, no included study reported surgical complications to have resulted from interference by IOL optics, and imaging quality for follow-up OCT scans was acceptable across studies (Kim and Jeon, 2022, Kim et al., 2021, Patel et al., 2019, Kamath et al., 2000a). Thus, while theoretical concern persists, current clinical data suggest that the currently available multifocal IOLs do not substantially hinder retinal imaging or posterior segment surgery.

Current ophthalmologist attitudes towards multifocal IOL use in retinal disease:

A qualitative survey by Lee et al. (2022) graded the perspectives of 111 Korean retinal specialists towards multifocal lens implantation in patients with 15 different retinal diseases on a 7-point Likert scale (Lee et al., 2022). The findings of this study broadly demonstrate a greater rate of retinal surgeon approval for multifocal lens use in eyes with less advanced macular sparing retinal diseases. AMD, diabetic retinopathy with macular oedema, previous retinal detachment and retinal vein occlusion were consistently rated as contraindications for multifocal technology from these surgeons' perspectives. Contrastingly, retinal conditions which typically cause lesser macular involvement such as dry AMD without geographic atrophy, high myopia and non-proliferative diabetic retinopathy without macular oedema, were more favourably rated. However, this qualitative survey demonstrated that the frequency of surgeon MIOL implantation and the type of ophthalmic surgical practice were key factors affecting specialist opinion as demonstrated by ANOVA ($p = 0.013$ and $p = 0.021$ respectively) (Lee et al., 2022). These data generally followed a trend of reporting more advanced macular-involving retinal pathology to be viewed as more unfavourable candidates for MIOL implantation by Korean retinal specialists, a finding that does not run contrary to the data from our systematic review.

Limitations and Future Directions:

The findings of this review are limited by the small sample sizes, no longitudinal follow up, and heterogeneity of design for each included study which each include different retinal pathologies and evaluate separate multifocal lenses with different comparators. Importantly, visual acuity and contrast sensitivity were reported with varying charts, conditions, and time points across studies. There is also insufficient evidence to determine ideal refractive targets based on the stage of co-existing retinal disease at the time of cataract surgery, which itself has been inconsistently defined in literature to date (Hinnig et al., 2022). Additionally, there is no evidence provided for long-term retinal outcomes given the lack of longitudinal data, and the implications of macular disease progression post-IOL implantation fell outside the scope of this review. This unanswered clinical question is of significance as it remains unknown whether multifocal lenses should be absolutely contraindicated in those at risk of progressive retinal disease, especially in the absence of clear long-term clinical data (Braga-Mele et al., 2014, Ehmann and Ho, 2017).

Similarly, it remains unknown at which point contrast sensitivity reductions from multifocal lenses are of clinical significance among those with comorbidities (Sánchez-Sánchez et al., 2021b, Chandra et al., 2021). Until such data are available, caution is reasonably warranted for multifocal IOL implantation in at least eyes with advanced retinal disease (Casparis et al., 2017, Cao et al., 2019).

This should be discussed and added as an important limitation.

Conclusion

The findings of this systematic review suggest that there is currently insufficient evidence to support routine exclusion of patients with co-existing retinal pathology from multifocal lens implantation. While strict cut-offs cannot be substantiated to guide when patients with retinal pathology would be disadvantaged from multifocal IOLs, there is preliminary evidence to suggest that visual and functional outcomes are more likely to be inferior when multifocal IOLs are used in eyes with more advanced retinal disease stages and retinal diseases involving the macula. Additionally, the implantation of multifocal lenses does not appear to have a negative impact upon the ability for retinal disease progress to be monitored and imaged.

Declarations

Clinical trial number

Not applicable.

Ethics and Consent to Participate declarations

Not applicable.

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Author Contribution

AM, SZ, NP, BB, SB were involved for the search, and data extraction and data analysis. AM, BB, WC, MG were all involved for the manuscript drafting. All authors reviewed and edited the manuscript.

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Figures

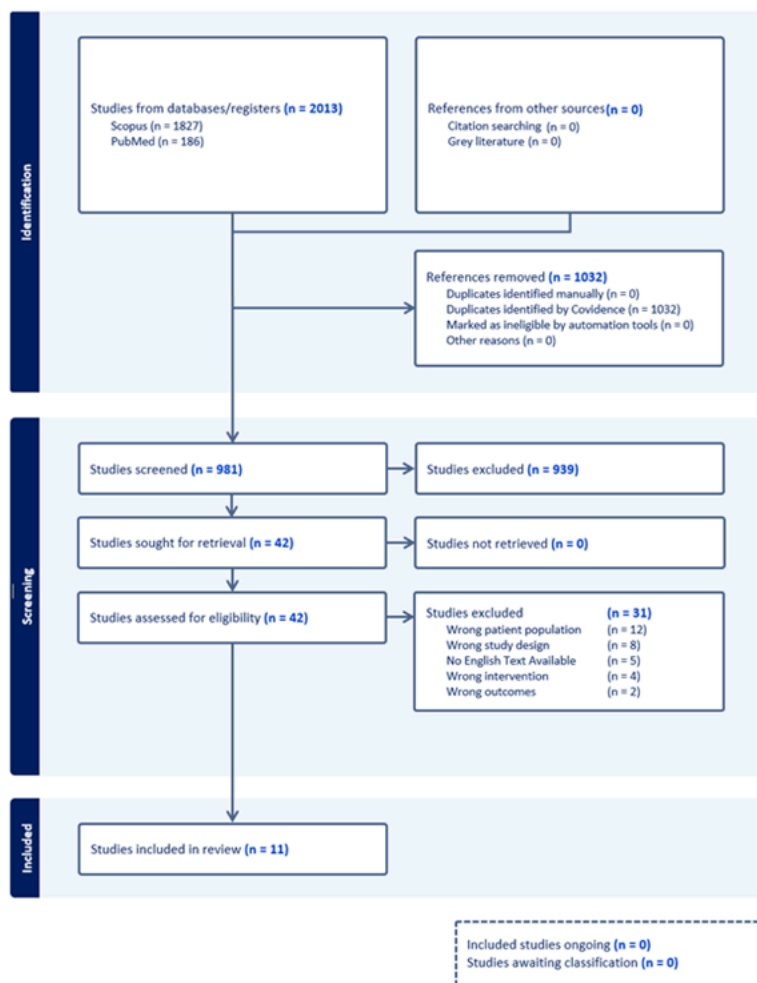


Figure 1

PRISMA framework detailing the search strategy and the application of the inclusion and exclusion criteria for articles that evaluated multifocal lens use in those with macular pathology

Supplementary Files

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