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COMPARATIVE VISUAL OUTCOMES, QUALITY OF VISION, AND SAFETY OF MULTIFOCAL AND EXTENDED DEPTH OF FOCUS INTRAOCULAR LENSES IN AGE-RELATED CATARACT: A SYSTEMATIC REVIEW

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Abstract

Introduction. Premium intraocular lenses (IOLs) enable presbyopia correction during cataract surgery. Multifocal IOLs create discrete foci, while extended depth of focus (EDOF) lenses provide a continuous range through aberration modification. Direct comparison is needed to guide clinical choices regarding effectiveness, safety, and visual phenomena (halos, glare).

Aim. To systematically compare visual functions, quality of vision, and safety of multifocal versus EDOF IOLs in age-related cataract.

Materials and methods. A systematic search was conducted in PubMed/MEDLINE and Google Scholar (January 2020 – April 2025). Inclusion criteria: adults with age-related cataract undergoing bilateral phacoemulsification with implantation of a premium IOL (multifocal, trifocal, EDOF, or hybrid), with direct comparison against another premium or monofocal IOL type and reporting quantitative postoperative visual outcomes. Studies without direct comparative data or with unilateral implantation were excluded. Methodological quality was assessed using the Jadad scale (RCTs) and the Newcastle–Ottawa Scale (observational studies). Fourteen primary comparative studies met inclusion criteria. Pooled meta-analysis was applied to extractable comparable outcomes using a random-effects model; remaining outcomes were narratively synthesized.

Results. EDOF and hybrid EDOF-multifocal IOLs showed advantages for intermediate visual acuity and broader functional range. Trifocal IOLs remained superior for near vision and spectacle independence. Distance vision was comparable across types. Photic phenomena frequency varied by design, but definitions were inconsistent.

Conclusion. Each type of premium IOL possesses a unique efficacy profile. The choice between multifocal and EDOF lenses should be based on an individual analysis of the patient's visual needs: a priority for near vision favors trifocal IOLs, while an emphasis on intermediate vision and visual quality in mesopic conditions favors EDOF IOLs.

Key words: cataract, multifocal IOLs, EDOF IOLs, trifocal IOLs, dysphotopsia.

Introduction. The evolution of cataract surgery from the simple restoration of optical media transparency to achieving refractive precision and presbyopia correction became possible due to the development of premium intraocular lenses (IOLs). Over the past two decades, patient expectations from cataract surgery have expanded considerably: individuals increasingly seek spectacle independence across a full range of distances, driving widespread adoption of presbyopia-correcting IOL technologies [1–3]. Historically, multifocal IOLs, creating several discrete foci through diffractive or refractive optics, were the first widely adopted solution for presbyopia correction during cataract surgery [4–6]. These lenses

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demonstrated clear advantages in near-vision performance and spectacle independence; however, their diffractive design was associated with an increased frequency of photic phenomena, including halos and glare, as well as reduced contrast sensitivity under mesopic conditions [1,2]. Subsequently, extended depth of focus (EDOF) lenses appeared, forming a continuous range of vision through wavefront modification, aberration engineering, or non-diffractive optical principles, offering a potentially more favorable visual-comfort profile [7–10]. More recently, hybrid EDOF-multifocal designs and enhanced monofocal lenses have further expanded the premium IOL landscape, challenging clinicians to navigate an increasingly complex decision-making environment. The growing diversity of available technologies has heightened the clinical need for direct comparative evidence to define clear indications for each IOL category, particularly for the multifocal versus EDOF comparison [3,11]. The relevance of a targeted comparative analysis is driven by the ongoing clinical debate regarding comparative effectiveness, safety – especially visual phenomena (halos, glare) – and subjective patient satisfaction across different lifestyles and visual demands [11–15]. The aim of this systematic review was to compare visual functions, quality of vision, and safety of premium intraocular lenses – including multifocal (trifocal), extended depth of focus (EDOF), and hybrid EDOF-multifocal designs – in patients with age-related cataract, with emphasis on the multifocal versus EDOF comparison.

Materials and methods.

Ethical issues

This study is a systematic review based exclusively on data from previously published studies. Therefore, approval by an institutional ethics committee and informed consent from participants were not required.

Study selection criteria

Inclusion criteria were defined according to the PICO concept. Patients (P): adults with age-related cataracts who underwent bilateral phacoemulsification with IOL implantation. Intervention (I): implantation of presbyopia-correcting IOLs (multifocal, trifocal, EDOF, hybrid). Comparison (C): implantation of a monofocal IOL (standard or “enhanced”) or direct comparisons between different types of premium IOLs. Outcomes (O): Primary: uncorrected (UCNVA) and corrected (DCNVA) near visual acuity, uncorrected intermediate (UIVA) and distance (UDVA) visual acuity, spectacle independence. Secondary: contrast sensitivity, frequency and severity of visual phenomena (halos, glare), depth of focus (defocus curves), patient satisfaction. Studies with unilateral implantation, without direct comparison of the IOL types of interest, and publications not providing quantitative data on key outcomes were excluded.

Information sources and search strategy

The search was conducted in PubMed/MEDLINE and Google Scholar for the period from January 2020 to April 2025. The last search was performed in April 2025. PubMed/MEDLINE was selected as the primary biomedical database because it provides indexed peer-reviewed ophthalmology and cataract-surgery literature. Google Scholar was used as a supplementary source for forward/backward citation tracking, manual checking of reference lists, and identification of potentially relevant records not indexed in PubMed. The PubMed/MEDLINE search string was: (("multifocal intraocular lens" OR "trifocal intraocular lens" OR "presbyopia-correcting intraocular lens") AND ("extended depth of focus" OR EDOF OR "enhanced monofocal") AND (cataract OR "cataract surgery") AND ("visual outcomes" OR "visual acuity" OR dysphotopsia OR halos OR glare OR "spectacle independence")). In Google Scholar, the first 300 records sorted by relevance were screened using the same key concepts. Embase, Scopus, and Web of Science were not searched; this was acknowledged as a limitation of the review.

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Study selection and data collection process

The selection process was conducted in two stages and checked by the authors. First, titles and abstracts were screened for relevance to the PICO question. Second, full texts were assessed against the inclusion and exclusion criteria. Duplicates were removed by comparing DOI, title, authors, year, and journal. Reasons for full-text exclusion were recorded. Data on authors, year of publication, study design, participant characteristics, types of compared IOLs, follow-up duration, outcomes, and quantitative data suitable for pooling were extracted into a standardized data table. Secondary reviews, protocols without results, and studies not providing direct comparative postoperative outcomes were not counted as primary included studies.

Assessment of methodological quality (risk of bias) in included studies

The quality of randomized controlled trials was assessed using the Jadad scale (randomization, blinding, and accounting for withdrawn patients are assessed). For observational studies (prospective cohorts and fellow-eye comparisons), the Newcastle–Ottawa Scale was used, assessing group selection, group comparability, and outcome assessment. The study-level assessment is presented in the Results section.

Synthesis of results

Data synthesis was performed in two complementary stages. First, all eligible primary comparative studies were summarized in a structured qualitative synthesis grouped by clinically relevant outcomes: distance, intermediate and near visual acuity, depth of focus, contrast sensitivity, dysphotopsias, spectacle independence, and patient satisfaction. Second, outcomes reported in a sufficiently homogeneous and extractable format across at least two studies were pooled quantitatively. Continuous outcomes were pooled as mean differences (MD) in logMAR with 95% confidence intervals (CI). Dichotomous outcomes were pooled as risk ratios (RR) with 95% CI. Because clinical heterogeneity was expected across IOL models and study designs, a random-effects model was applied. Statistical heterogeneity was assessed using I^2. Leave-one-out sensitivity analysis was planned when at least three studies were available for an outcome; otherwise, the limited number of studies was explicitly stated.

Results.

Study selection

The initial search yielded 340 records (PubMed/MEDLINE: 40; Google Scholar supplementary search: first 300 records sorted by relevance). After removal of 24 duplicates, 316 records were screened by title and abstract. Of these, 285 records were excluded as irrelevant by topic, study type, or outcome. Thirty-one reports were sought for retrieval; 4 full texts could not be obtained. Twenty-seven full-text articles were assessed for eligibility, and 13 were excluded for the following reasons: no direct relevant comparison, secondary review or meta-analysis, study protocol without results, visual-training/neuroadaptation design without a relevant IOL comparison, unilateral implantation, or insufficient extractable comparative data. Fourteen primary comparative clinical reports were included in the systematic synthesis. Four studies provided sufficiently comparable extractable data for the limited quantitative meta-analysis. The selection process is detailed in the PRISMA flowchart (Figure 1).

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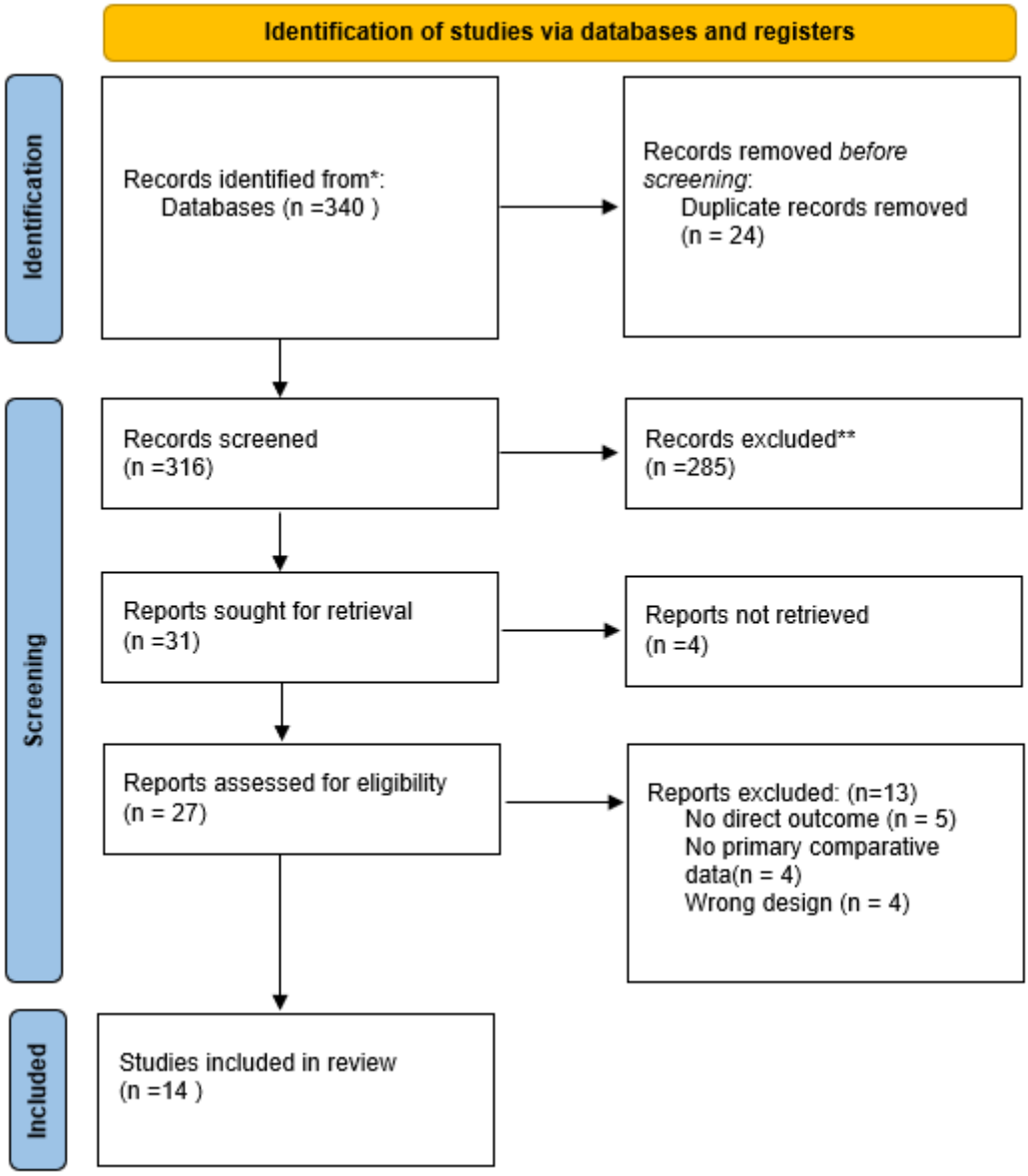


Figure 1. PRISMA flow diagram.

Study characteristics

The 14 included primary comparative reports were published between 2021 and 2025 and included randomized controlled trials, prospective randomized masked studies, prospective comparative non-randomized studies, and one fellow-eye comparison study. Reports without original comparative postoperative outcomes, including another systematic review, a study protocol, and a visual-training/neuroadaptation trial, were not counted as primary included studies in the synthesis. The main compared IOL models included trifocal IOLs, hybrid multifocal EDOF lenses, nondiffractive and refractive EDOF lenses, and enhanced or standard monofocal IOLs. Detailed characteristics of the included primary studies are presented in Table 1.

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Table 1. Characteristics of included studies.

№	Author, year	Study design (S)	Participants (P)	Intervention (I)	Comparison (C)	Main outcomes (O)	Key results	Authors' conclusions
1.	Dick et al., 2022 [11]	Prospective comparative	150 patients (bilateral)	ZFR00V (hybrid multifocal EDOF)	TFNT00 (trifocal)	Visual acuity (distance, intermediate, near), defocus curve, photic phenomena, safety.	ZFR00V showed better near visual acuity (33 cm) and mesopic vision ($p \leq 0.05$). Broader defocus curve. Photic phenomena were comparable.	ZFR00V provides a wider depth of focus and better near vision, especially in low-light conditions.
2.	Kim et al., 2025 [16]	Randomized, three-group	75 patients (25 per group)	Gr.1: bilateral hybrid multifocal. Gr.2: EDOF (dom.) + hybrid.	Gr.3: enhanced monofocal (dom.) + hybrid.	Visual acuity, defocus curves, contrast sensitivity (CS), reading speed, questionnaires.	Gr.1 and 2 were superior at intermediate distance compared to Gr.3 ($p=0.030$). Gr.1 had better reading speed but more photic phenomena.	Bilateral hybrid multifocal IOLs provide better near vision but more photic phenomena. Combinations allow for individualization.
3.	Ivellio-Vellin et al., 2024 [17]	Prospective comparative	28 patients (14 per group)	ARTIS SYMBIOSE (binary complementary EDOF)	AT LARA (low-addition multifocal)	Visual acuity, defocus curves, CS, halos, reading speed.	No difference in visual acuity ($p>0.05$). ARTIS SYMBIOSE was better in CS under certain conditions ($p<0.05$).	Both IOLs provide good vision. ARTIS SYMBIOSE has an advantage in contrast sensitivity.
4.	Ozturkmen et al., 2022 [12]	Prospective comparative	50 patients (bilateral)	ZFR00V (hybrid EDOF-multifocal)	TFNT00 (trifocal)	Visual acuity, defocus curve, VF-14 (quality of vision).	ZFR00V was better at intermediate distance ($p=0.02$) and in the defocus range of −1.00 to −1.50 D. VF-14 scores were comparable.	ZFR00V provides better intermediate vision with similar quality of life.
5.	Reinhard et al., 2021 [18]	Multicenter randomized clinical trial (RCT)	211 patients	Two types of EDOF IOLs: AT LARA 829MP and TECNIS Symfony (ZXR00)	Monofocal IOL ASPHINA (CT ASPHINA 409MP)	Depth of focus (mono-/binocular), VA (distance, intermediate, near), CS, spectacle independence, safety.	Monocular depth of focus was better for AT LARA vs Symfony ($p=0.024$–0.006). Binocular depth of focus for both EDOFs was better than monofocal ($p<0.0001$, $p=0.002$). Distance VA was equal; intermediate and near VA were better for EDOFs ($p<0.0001$). CS was higher for the monofocal IOL. Spectacle independence was superior with EDOFs. No safety issues identified.	Both EDOF IOLs (AT LARA and Symfony) provide significantly greater depth of focus and better intermediate/near vision compared to monofocal IOLs, while maintaining excellent distance vision and a safe profile.

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№	Author, year	Study design (S)	Participants (P)	Intervention (I)	Comparison (C)	Main outcomes (O)	Key results	Authors' conclusions
6.	Sevik et al., 2022 [13]	Prospective randomized	29 patients (with mini-monovision)	ZXR00 (EDOF Symfony)	ZKB00 (low-addition multifocal)	Visual acuity, CS, spectacle need, photic phenomena, quality of life (NEI RQL-42).	EDOF was better at intermediate and near distances (p=0.046), had a better defocus curve (−0.50 to −1.75 D), and better mesopic CS.	EDOF with mini-monovision provides better uncorrected visual acuity at intermediate and near distances.
7.	Black et al., 2024 [19]	Prospective randomized	Subgroup with refractive error >0.25 D	ZEN00V (refractive EDOF PureSee)	ICB00 (enhanced monofocal Eyhance)	Visual acuity, error tolerance, symptoms, satisfaction.	ZEN00V maintains high distance quality and a monofocal dysphotopsia profile even with refractive error.	Refractive EDOF IOL demonstrates high tolerance to refractive errors.
8.	Danzinger et al., 2024 [15]	Prospective, fellow-eye comparison	25 patients (50 eyes)	Isopure (monofocal EDOF) in dominant eye	FineVision Triumf (trifocal EDOF) in non-dominant eye	Visual acuity, defocus curves, aberrations, subjective outcomes.	Triumf was better for near (p<0.001). Isopure was similar at distance and intermediate. Both had low photic phenomena.	Triumf is better for near. Isopure provides similar distance and intermediate vision with low photic phenomena.
9.	Corbett et al., 2024 [20]	Prospective randomized masked	117 patients (bilateral)	ZEN00V (EDOF PureSee)	ICB00 (enhanced monofocal Eyhance)	Visual acuity, depth of focus, CS, visual symptoms.	ZEN00V was better at intermediate (p=0.0127) and near (p=0.0137) distances. Distance, CS, and symptoms were comparable.	EDOF IOL extends the range of vision, improving intermediate and near vision without compromising distance or CS.
10.	Wanten et al., 2025 [21]	Prospective RCT	31 patients (with mini-monovision)	Acunex Vario (EDOF)	AcrySof IQ Vivity (EDOF)	Visual acuity, defocus curves, reading speed, CS, spectacle independence.	No significant differences in visual acuity (p>0.05). Vario had a larger defocus range. Quality of vision parameters were comparable.	Both EDOF IOLs with mini-monovision provide clinically comparable visual results.
11.	Zeilinger et al., 2025 [22]	RCT, double-masked	40 patients (with mini-monovision)	DFT015 (Vivity, non-diffractive EDOF)	RAO200E (RayOne EMV, enhanced monofocal)	Visual acuity, CS, defocus curves, halos, questionnaire.	Binocularly – no difference. Monocularly, DFT015 was better at intermediate and near in the dominant eye (p<0.05). RAO200E – fewer halos.	Both IOLs under mini-monovision conditions provide similar binocular vision at all distances.

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№	Author, year	Study design (S)	Participants (P)	Intervention (I)	Comparison (C)	Main outcomes (O)	Key results	Authors' conclusions
12.	Chang et al., 2022 [10]	Prospective randomized masked	299 patients (bilateral)	ZXR00 (EDOF Symfony)	ZCB00 (monofocal)	Visual acuity, spectacle wear, visual symptoms.	Symfony was comparable at distance, better at intermediate and near ($p<0.0001$). Less spectacle wear (85% vs 59.9%). Low incidence of dysphotopsia.	Symfony improves intermediate and near vision and reduces spectacle dependence with low dysphotopsia rates.
13.	Pantanelli et al., 2023 [6]	RCT, double-masked	51 patients (bilateral)	AcrySof Vivity (non-diffractive EDOF)	enVista (monofocal)	Visual acuity, spectacle independence, photic phenomena.	Vivity was better at intermediate ($p<0.001$) and near ($p=0.004$) distances (by ~2 lines). More spectacle independence. Photic phenomena were low and comparable.	Vivity provides better vision at intermediate and near distances and greater spectacle independence.
14.	Han et al., 2025 [23]	Prospective randomized	100 patients (bilateral)	Tecnis ZMB00 (multifocal)	Aspheric monofocal	Visual acuity, visual quality, spectacle independence, quality of life, complications.	Multifocal: better visual acuity, quality of life, and spectacle independence ($p<0.05$). However, lower CS and more photic phenomena (halos/glare).	Multifocal IOL improves quality of life and independence but has more optical side effects.

Note: The study protocol [24], secondary systematic reviews/meta-analyses, and visual-training/neuroadaptation trial [25] were excluded from the primary synthesis and were retained only as contextual references where appropriate. Abbreviations: VA – visual acuity (distance, intermediate, near); CS – contrast sensitivity; dom. – dominant (eye); UDVA – uncorrected distance visual acuity; UIVA – uncorrected intermediate visual acuity; UNVA – uncorrected near visual acuity; RCT – randomized controlled trial; IOL – intraocular lens; EDOF – extended depth of focus; D – diopter; F/U – follow-up; bino – binocular.

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Risk of bias assessment in the included studies

The risk of bias was assessed separately for each included primary comparative study using a design-appropriate tool. Randomized trials were assessed using the Jadad scale, whereas prospective comparative and fellow-eye studies were assessed using the Newcastle–Ottawa Scale. Most randomized studies were of moderate to good quality, mainly limited by incomplete masking or small sample size. Observational and fellow-eye studies generally demonstrated acceptable selection and outcome assessment, but residual confounding related to non-randomized allocation remained possible. The individual assessment is presented in Table 2.

Table 2. Study-level risk-of-bias assessment.

Study	Design / tool	Score	Overall judgement and main limitation
Dick et al., 2022 [11]	Prospective comparative / NOS	7/9	Good; non-randomized design may leave residual confounding.
Kim et al., 2025 [16]	Randomized three-group / Jadad	3/5	Moderate; masking and attrition reporting not fully detailed.
Ivellio-Vellin et al., 2024 [17]	Prospective comparative / NOS	6/9	Moderate; small groups and possible baseline-comparability limitations.
Ozturkmen et al., 2022 [12]	Prospective comparative / NOS	6/9	Moderate; direct comparison, but allocation was not randomized.
Reinhard et al., 2021 [18]	Multicenter RCT / Jadad	4/5	Good; complete masking not always feasible in IOL trials.
Sevik et al., 2022 [13]	Prospective randomized / Jadad	3/5	Moderate; small sample and limited masking information.
Black et al., 2024 [19]	Prospective randomized / Jadad	3/5	Moderate; subgroup focus and limited masking detail.
Danzinger et al., 2024 [15]	Prospective fellow-eye / NOS	7/9	Good; within-patient comparison reduces confounding, but allocation may remain non-random.
Corbett et al., 2024 [20]	Prospective randomized masked / Jadad	4/5	Good; masked randomized design with relevant patient-reported outcomes.
Wanten et al., 2025 [21]	Prospective RCT / Jadad	4/5	Good; randomized design, but small sample limits precision.
Zeilinger et al., 2025 [22]	Double-masked RCT / Jadad	4/5	Good; mini-monovision setting may limit generalizability.
Chang et al., 2022 [10]	Prospective randomized masked / Jadad	4/5	Good; pivotal device trial context considered in interpretation.
Pantanelli et al., 2023 [6]	Double-masked RCT / Jadad	4/5	Good; symptom/outcome definitions differ from other trials.
Han et al., 2025 [23]	Prospective randomized / Jadad	3/5	Moderate; allocation/masking details were limited in the report.

Near visual acuity

A structured synthesis confirmed that trifocal IOLs usually provide strong near-vision performance because of a dedicated near focal point. However, quantitative pooling was restricted to extractable and comparable 40-cm near-acuity data. In this limited subset, the

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pooled MD was −0.054 logMAR (95% CI: −0.084 to −0.024; I^2=0%), favoring EDOF/hybrid EDOF arms for the specific 40-cm endpoint. This result was not generalized to all near-vision distances because some studies reported near acuity at 33 cm or used different measurement protocols.

Intermediate vision

Intermediate visual acuity was the outcome most consistently favoring EDOF and hybrid EDOF designs. Extractable data from three studies were pooled using a random-effects model and showed a small but statistically significant advantage for EDOF/hybrid EDOF arms (MD −0.024 logMAR; 95% CI: −0.041 to −0.008; I^2=0%). This supports the clinical interpretation that EDOF optics are particularly useful for intermediate-distance tasks, including computer and digital-device use.

Distance vision

All included studies confirmed that both multifocal and EDOF IOLs provide distance visual acuity (UDVA) comparable to that of high-quality monofocal lenses. Binocular UDVA often reached 1.0 (decimal) or better. For example, in the study by Choi et al. (2020) [8], 98% of patients implanted with Symfony achieved visual acuity of 0.8 or better.

Depth of focus and defocus curves

Analysis of defocus curves revealed a key conceptual difference. EDOF IOLs provide a smoother and more extended functional range. Dick et al. (2022) [11] showed that the hybrid EDOF ZFR00V had a 0.4 D wider range for achieving 20/32 visual acuity compared with the trifocal TFNT00. Reinhard et al. (2021) [18] likewise reported that both monocular and binocular depth of focus with EDOF IOLs (AT LARA, Symfony) was significantly greater than with monofocal lenses.

Contrast sensitivity

Results for this outcome were heterogeneous, but the overall trend favored EDOF and nondiffractive IOLs, particularly under mesopic conditions and in the presence of glare. Ivellio-Vellin et al. (2024) [17] found that the EDOF IOL ARTIS SYMBIOSE outperformed the low-add multifocal AT LARA in contrast sensitivity at 1.5 and 3 cpd under mesopic conditions with glare (p=0.002 and p=0.006, respectively). Similarly, Reinhard et al. (2021) [18] reported that contrast sensitivity at high spatial frequencies remained higher in the monofocal IOL group compared with EDOF IOLs; however, EDOF lenses performed better than traditional multifocal designs.

Visual phenomena (dysphotopsias)

A limited quantitative synthesis was possible for bothersome or moderate-to-severe halos. The pooled RR was 1.83 (95% CI: 0.64 to 5.23; I^2=0%), indicating no statistically significant difference in this limited extractable subset. However, interpretation was cautious because symptom definitions, grading thresholds, and questionnaires differed between studies. Overall, nondiffractive EDOF designs tended to show a more favorable dysphotopsia profile, whereas diffractive multifocal designs were more frequently associated with halos or glare in individual studies.

Spectacle independence and patient satisfaction

Spectacle independence was reported in several studies but was not pooled because definitions differed substantially across reports, including complete independence, distance-specific independence, or questionnaire-based estimates. Therefore, this outcome was synthesized narratively. Trifocal IOLs generally provided strong near-spectacle independence, while EDOF IOLs demonstrated high functional independence for distance and intermediate activities with fewer visual-quality complaints in selected studies.

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Heterogeneity and sensitivity analysis

Statistical heterogeneity was low in the limited pooled analyses (I^2=0% for intermediate VA, near VA at 40 cm, and bothersome/moderate-to-severe halos), but this should be interpreted cautiously because the number of studies was small. Leave-one-out sensitivity analysis was not performed for outcomes with fewer than three studies; for the intermediate-vision analysis, inspection of individual study estimates did not show directional inconsistency. The limited scope of quantitative pooling is acknowledged as a methodological limitation. Quantitative findings for intermediate visual acuity, near visual acuity at 40 cm, and bothersome halos are presented in Table 3, with forest plots shown in Figure 2.

Table 3. Quantitative synthesis of extractable outcomes.

Outcome	**Effect measure**	**Pooled estimate (95% CI)**	**Heterogeneity / sensitivity**	**Clinical interpretation**
Intermediate visual acuity	MD, logMAR	−0.024 (−0.041 to −0.008)	I^2=0%; 3 studies; random-effects model	Small but statistically significant advantage favoring EDOF/hybrid EDOF arms
Near visual acuity at 40 cm	MD, logMAR	−0.054 (−0.084 to −0.024)	I^2=0%; 2 studies; random-effects model	Extractable 40-cm subset favored EDOF/hybrid arms; not generalized to all near endpoints
Bothersome / moderate-to-severe halos	RR	1.83 (0.64 to 5.23)	I^2=0%; 2 studies; random-effects model	No statistically significant difference; symptom definitions varied across studies
Spectacle independence	Not pooled	Not pooled	Different questionnaires and distance-specific thresholds	Reported narratively because definitions were not sufficiently comparable

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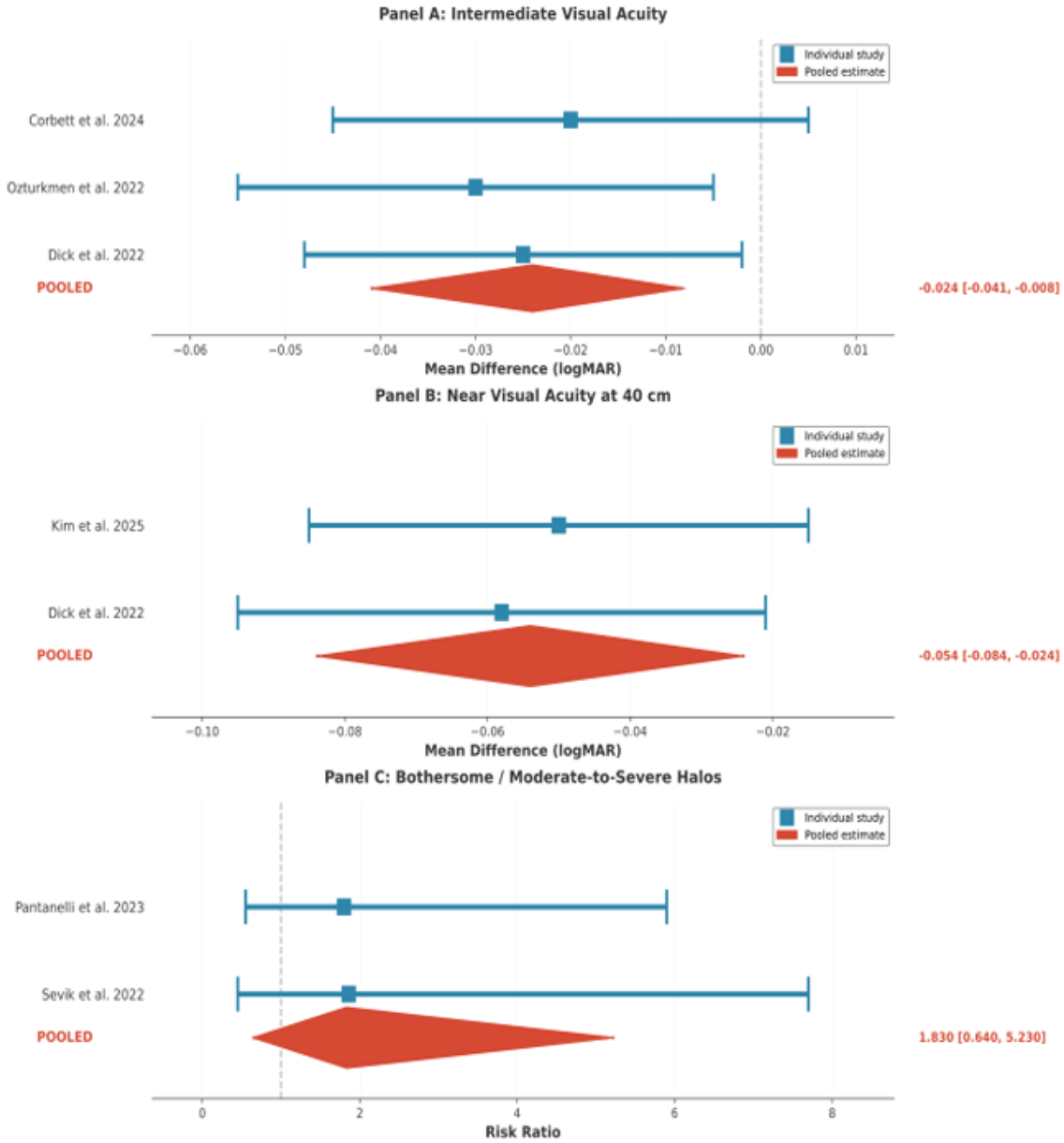


Figure 2. Forest plot summary for outcomes included in the limited extraction-based meta-analysis.

Discussion. This systematic review, based on 14 primary comparative clinical reports, provides a clinically focused synthesis of the efficacy and safety profiles of contemporary premium intraocular lenses (IOLs). Trifocal IOLs remain highly effective for near vision and spectacle independence, while EDOF and hybrid EDOF-multifocal IOLs provide a broader functional range, particularly for intermediate-distance tasks, with a generally favorable visual-comfort profile. Therefore, the review offers practical evidence for individualized IOL selection rather than a single universal ranking of lens types.

The performance of trifocal IOLs for near vision is well established. In the included studies, trifocal designs consistently provided strong uncorrected near visual acuity at 33–40 cm and higher rates of spectacle independence compared with EDOF and enhanced monofocal lenses [11,12,15]. This advantage is attributed to the dedicated near focal point inherent to diffractive trifocal optics. However, trifocal IOLs were more frequently associated with photic

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phenomena, particularly halos and glare, which may affect patient satisfaction, especially in low-light environments [14,15]. Neuroadaptation over time can partially mitigate these complaints, but the extent and timeline of adaptation remain incompletely characterized in the available literature [25–27]. In contrast, EDOF IOLs, including hybrid designs, offer a different conceptual approach. Their main strength lies in providing a continuous and smooth range of vision, which results in superior performance at intermediate distances (60–80 cm), a zone that is critically important for modern digital activities [6,12,18,21]. This advantage is complemented by a broader functional depth of focus [11,18] and, in general, a more favorable profile of visual artifacts and contrast sensitivity [17,28], contributing to better subjective adaptation and higher satisfaction in everyday life. The comparison between multifocal and EDOF IOLs is further complicated by the heterogeneity of lens designs within each category.

Non-diffractive EDOF lenses (such as the AcrySof Vivity) demonstrated a dysphotopsia profile comparable to monofocal IOLs [13,20], while diffractive EDOF designs showed intermediate rates of photic phenomena between trifocal and monofocal lenses. Similarly, hybrid EDOF-multifocal lenses represent an attempt to combine the continuous depth of focus of EDOF optics with improved near-vision performance [11,12]. These design differences make it impossible to draw uniform conclusions for each category as a whole, underscoring the need for individualized lens selection. The concept of mini-monovision – targeting a mild myopic refraction in the non-dominant eye – was applied in several included studies and emerged as a clinically effective strategy to extend functional vision with either EDOF or enhanced monofocal IOLs [13,21,22]. This approach may reduce the need for a dedicated near focal point while maintaining a favorable visual-quality profile, representing an important option for patients who prioritize minimal photic phenomena. From the perspective of patient-reported outcomes, both trifocal and EDOF IOLs generally achieved high levels of satisfaction. However, the domains driving satisfaction differed. Trifocal IOL patients reported greater reading ability and spectacle freedom, while EDOF IOL patients reported fewer bothersome visual symptoms and more consistent intermediate-distance performance [11,19,20]. These complementary profiles reinforce the view that multifocal and EDOF lenses serve different patient needs rather than competing for the same clinical niche. Compared with existing systematic reviews and meta-analyses on this topic [1–3], the present review specifically focused on primary comparative clinical reports published from 2020 to 2025, thereby capturing the most recent generation of premium IOL designs. The inclusion of hybrid and non-diffractive EDOF lenses, which were not represented in earlier reviews, is a notable strength of this synthesis.

Study limitations

Interpretation of the results is limited by the methodological heterogeneity of the included studies, differences in follow-up duration, and the lack of standardized instruments for assessing dysphotopsias and patient satisfaction. Most studies had relatively short follow-up periods (3–6 months), which may not adequately capture long-term neuroadaptation, particularly with respect to visual phenomena. In addition, nearly all studies included patients with low preoperative astigmatism and without significant retinal pathology, limiting the generalizability of the findings to the broader cataract population. The search was limited to PubMed/MEDLINE and Google Scholar; Embase, Scopus, and Web of Science were not searched. Google Scholar was used as a supplementary source, which improves citation tracking but is less reproducible than indexed bibliographic databases. Finally, quantitative pooling was restricted to outcomes with extractable and comparable data, so several clinically relevant outcomes were synthesized narratively.

Conclusion. Based on a systematic analysis of 14 primary comparative clinical reports with limited extraction-based meta-analysis for selected outcomes, multifocal (trifocal) and

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EDOF intraocular lenses should be regarded as complementary rather than competing technologies. Trifocal IOLs provide strong near-vision performance and spectacle independence, whereas EDOF and hybrid EDOF-multifocal IOLs demonstrate advantages in intermediate vision and functional range with a generally favorable visual-comfort profile. Optimal outcomes require personalized IOL selection based on the patient's visual demands, lifestyle factors, and tolerance for potential optical trade-offs.

Conflict of interest. The authors declare no conflict of interest.

Authors' contribution. Concept, MR, NA, LO; methodology, MR, ZU; writing – preparation of the manuscript, MR; writing – review and editing, MR, NA, LO, ZU; project administration, MR, NA. All authors have read and agreed to the published version of the manuscript. The authors declare that this material has not been previously published and is not under consideration by other publishers.

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ЖАСҚА БАЙЛАНЫСТЫ КАТАРАКТА КЕЗІНДЕГІ МУЛЬТИФОКАЛЬДЫ КӨЗІШІЛІК ЛИНЗАЛАР МЕН КЕҢЕЙТІЛГЕН ФОКУС ТЕРЕҢДІГІ БАР КӨЗІШІЛІК ЛИНЗАЛАРДЫҢ САЛЫСТЫРМАЛЫ ВИЗУАЛДЫҚ НӘТИЖЕЛЕРІ, КӨРУ САПАСЫ ЖӘНЕ ҚАУІПСІЗДІГІ: ЖҮЙЕЛІ ШОЛУ

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Түйіндеме

Кіріспе. Премиум интраокулярлы линзалар (ИОЛ) катаракта хирургиясы кезінде пресбиопияны түзетуге мүмкіндік береді. Мультифокальды ИОЛ бірнеше дискретті фокустар жасайды, ал кеңейтілген фокус тереңдігі (EDOF) линзалары аберрацияларды модификациялау арқылы үздіксіз көру диапазонын қамтамасыз етеді. Тиімділік, қауіпсіздік және фотофеномендер (гало, жарқыл) бойынша клиникалық таңдауды бағыттау үшін тікелей салыстыру қажет.

Мақсаты. Егде жас катарактасында мультифокальды және EDOF ИОЛ-дың көру функцияларын, көру сапасы мен қауіпсіздігін жүйелі түрде салыстыру.

Материалдар мен әдістер. PubMed/MEDLINE және Google Scholar дерекқорларында жүйелі іздеу жүргізілді (қаңтар 2020 – сәуір 2025). Қосу критерийлері: жасқа байланысты катарактасы бар ересек науқастар, екі жақты факоэмульсификация мен премиалды ИОЛ имплантациясынан өткен; басқа ИОЛ түрімен тікелей салыстыру болуы және сандық операциядан кейінгі нәтижелер болуы тиіс. Тікелей салыстырмалы деректері жоқ немесе бір жақты имплантация жасалған зерттеулер алынып тасталды. Жадад шкаласы (РКЗ) және Ньюкасл–Оттава шкаласы (бақылау зерттеулері) бойынша методологиялық сапа бағаланды. Он төрт бастапқы салыстырмалы зерттеу қосу критерийлеріне сәйкес келді. Салыстырмалы нәтижелерге кездейсоқ эффекттер моделін қолдана отырып мета-талдау жүргізілді; қалғандары нарративті түрде жинақталды.

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Нәтижелер. EDOF және гибридті мультифокальды-EDOF ИОЛ аралық көру өткірлігі мен кең функционалдық диапазонда артықшылықтар көрсетті. Трифокальды ИОЛ жақыннан көру және көзілдіріксіздік бойынша үздік болды. Алыстан көру өткірлігі барлық типтерде салыстырмалы болды. Фотофеномендердің жиілігі дизайнға байланысты өзгерді, бірақ анықтамалар біркелкі емес еді.

Қорытынды. Премиум ИОЛ-дың әрбір түрі тиімділіктің бірегей профиліне ие. Мультифокальды және EDOF линзалар арасындағы таңдау пациенттің көру қажеттіліктерін жеке талдауға негізделуі тиіс: жақыннан көру басымдығы трифокальды ИОЛ-ға қолайлы, ал аралық көру мен мезопиялық жағдайдағы көру сапасына баса назар аудару EDOF ИОЛ-ға қолайлы.

Түйінді сөздер: катаракта, мультифокальды ИОЛ, EDOF ИОЛ, трифокальды ИОЛ, дисфотопсия.

СРАВНИТЕЛЬНЫЕ ЗРИТЕЛЬНЫЕ ИСХОДЫ, КАЧЕСТВО ЗРЕНИЯ И БЕЗОПАСНОСТЬ МУЛЬТИФОКАЛЬНЫХ ИНТРАОКУЛЯРНЫХ ЛИНЗ И ИНТРАОКУЛЯРНЫХ ЛИНЗ С РАСШИРЕННОЙ ГЛУБИНОЙ ФОКУСА ПРИ ВОЗРАСТНОЙ КАТАРАКТЕ: СИСТЕМАТИЧЕСКИЙ ОБЗОР

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Аннотация

Введение. Современные интраокулярные линзы (ИОЛ) позволяют корригировать пресбиопию во время хирургии катаракты. Мультифокальные ИОЛ создают несколько дискретных фокусов, тогда как линзы с расширенной глубиной фокуса (EDOF) обеспечивают непрерывный диапазон зрения за счет модификации аберраций. Прямое сравнение необходимо для выбора оптимальной тактики с учетом эффективности, безопасности и фотофеноменов (гало, блики).

Цель. Систематически сравнить зрительные функции, качество зрения и безопасность мультифокальных ИОЛ и ИОЛ с расширенной глубиной фокуса при возрастной катаракте.

Материалы и методы. Проведен систематический поиск в базах данных PubMed/MEDLINE и Google Scholar за период с января 2020 г. по апрель 2025 г. Критерии включения: взрослые пациенты с возрастной катарактой, перенесшие двустороннюю факоэмульсификацию с имплантацией премиальной ИОЛ (мультифокальной, трифокальной, EDOF или гибридной), при наличии прямого сравнения с другим типом ИОЛ и количественными данными о послеоперационных зрительных функциях. Исследования без прямого сравнительного дизайна или с односторонней имплантацией исключались. Оценка методологического качества проводилась по шкале Jadad (РКИ) и шкале Ньюкасла–Оттавы (наблюдательные исследования). Четырнадцать первичных сравнительных исследований соответствовали критериям включения. Для сопоставимых исходов применен метаанализ (модель случайных эффектов); остальные данные обобщены нарративно.

Результаты. ИОЛ EDOF и гибридные мультифокальные EDOF показали преимущества в промежуточной остроте зрения и более широком функциональном

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диапазоне. Трифокальные ИОЛ оставались лучшими для ближнего зрения и независимости от очков. Острота дальнего зрения была сопоставима между типами. Частота фотофеноменов варьировала в зависимости от дизайна, но определения были неоднородными.

Заключение. Каждый тип премиальной ИОЛ обладает уникальным профилем эффективности. Выбор между мультифокальными и EDOF линзами должен основываться на индивидуальном анализе зрительных потребностей пациента: приоритет ближнего зрения предпочтителен для трифокальных ИОЛ, тогда как акцент на промежуточном зрении и качестве зрения в мезопических условиях – для EDOF ИОЛ.

Ключевые слова: катаракта, мультифокальные ИОЛ, EDOF ИОЛ, трифокальные ИОЛ, дисфотопсия.

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