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Advantages of Next-Generation Intraocular Lenses in Cataract Surgery: A Narrative Review

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ABSTRACT

Cataract remains a leading cause of visual impairment worldwide, with surgical extraction and intraocular lens (IOL) implantation representing the standard of care. In recent years, the development of next-generation extended depth-of-focus (EDOF) intraocular lenses has transformed cataract surgery from a purely restorative procedure into a refractive intervention aimed at achieving functional vision across multiple distances. This narrative review evaluates the optical principles, clinical performance, and patient-reported outcomes associated with EDOF IOLs, with a focus on their advantages over conventional monofocal and multifocal lenses. A comprehensive review of peer-reviewed literature published between 2016 and 2026 was conducted, including randomized controlled trials, observational studies, and systematic reviews. Evidence indicates that EDOF IOLs provide superior uncorrected intermediate and near visual acuity compared with monofocal lenses, while maintaining comparable distance vision and contrast sensitivity. In comparison with trifocal and multifocal IOLs, EDOF lenses demonstrate improved optical quality and reduced incidence of photic phenomena such as halos and glare, albeit with slightly reduced near vision performance. Patient-reported outcomes consistently highlight enhanced satisfaction, particularly in daily activities requiring intermediate vision, including computer use and low-light tasks. Emerging non-diffractive EDOF technologies further optimize visual quality and safety profiles. Additionally, mix-and-match implantation strategies show promise in balancing visual range and minimizing visual disturbances. Overall, next-generation EDOF IOLs offer a favorable compromise between visual range, quality, and safety. Personalized patient selection and counseling remain essential to optimize outcomes, while future research should focus on long-term effectiveness and quality-of-life measures.

1. Introduction

Cataract is one of the leading causes of visual impairment worldwide, accounting for approximately 51% of all cases of blindness globally [1]. Surgical removal of the crystalline lens with implantation of an intraocular lens (IOL) remains the definitive treatment, and it is one of the most frequently performed surgical procedures in medicine [2]. Over the past three decades, cataract surgery has evolved remarkably, shifting from a procedure aimed solely at restoring functional distance vision to one that aspires to achieve spectacle independence across multiple distances [3].

The introduction of presbyopia-correcting IOLs represented a paradigm shift in refractive outcomes after cataract surgery. Monofocal IOLs, while effective at providing excellent distance vision, require patients to use reading glasses for intermediate and near tasks. Multifocal IOLs addressed this limitation by generating discrete focal points but were associated with photic phenomena, including halos and glare, as well as reduced contrast sensitivity, limiting their use in certain patient populations [4, 5].

Extended depth-of-focus (EDOF) intraocular lenses represent the next generation of premium IOL technology, designed to bridge the gap between monofocal and multifocal lenses. By elongating the focal zone rather than creating discrete foci, EDOF lenses aim to provide a continuous, functional range of vision from intermediate to far distances while minimizing the dysphotopsic phenomena associated with multifocal designs [6]. This narrative review summarizes the available evidence on the clinical advantages, optical principles, and comparative outcomes of next-generation EDOF IOLs in cataract surgery.

1.1 Background and Historical Context

The first commercially available EDOF IOL, the Tecnis Symfony® (Johnson & Johnson Surgical Vision), received FDA approval in 2016. It employed echelette diffractive technology combined with achromatic design to create an elongated focus and correct chromatic aberration, representing a significant departure from conventional bifocal or trifocal designs [7]. Subsequent generations of EDOF IOLs have adopted diverse optical strategies, including non-diffractive wavefront-shaping technologies, central zone modifications, and hybrid refractive-diffractive platforms, further expanding the clinical armamentarium available to ophthalmic surgeons.

1.2 Objectives

This review aims to (a) describe the main optical principles underlying EDOF IOL design; (b) summarize clinical evidence comparing EDOF IOLs with monofocal and trifocal alternatives; (c) evaluate patient-reported outcomes and satisfaction; and (d) discuss emerging technologies and future directions in premium IOL selection.

2. Literature Review

The clinical evidence base for EDOF IOLs has expanded substantially since the approval of the Symfony platform. A systematic review and meta-analysis including nine comparative clinical trials with a total of 1,336 eyes demonstrated that, compared with monofocal IOLs, EDOF IOLs produced significantly better uncorrected intermediate visual acuity (weighted mean difference [WMD]: -0.17 logMAR; 95% CI: -0.26 to -0.08; P = 0.0001) and better uncorrected near visual acuity (WMD: -0.17 logMAR; 95% CI: -0.21 to -0.12; P < 0.00001) [3]. EDOF IOLs also conferred higher spectacle independence (risk ratio: 2.81; 95% CI: 1.06–7.46; P = 0.04), though at the cost of a higher incidence of halos and slightly reduced contrast sensitivity compared with monofocal lenses.

2.1 Comparison with Monofocal IOLs

When compared directly to enhanced monofocal lenses such as the Eyhance™ (ICB00, Johnson & Johnson), the next-generation TECNIS PureSee™ EDOF (ZEN00V) demonstrated statistically superior uncorrected intermediate (0.11 ± 0.08 vs. 0.17 ± 0.11 logMAR; p = 0.006) and uncorrected near visual acuity (0.25 ± 0.08 vs. 0.31 ± 0.13 logMAR; p = 0.023) at three months postoperatively, while maintaining comparable distance visual acuity and contrast sensitivity [8]. Spectacle dependence for near vision was significantly lower in the EDOF group (36% vs. 80%; p = 0.002), reflecting a clinically meaningful advantage for daily activities.

2.2 Comparison with Trifocal and Multifocal IOLs

Compared with trifocal IOLs, EDOF lenses have generally demonstrated inferior near visual acuity but superior contrast sensitivity, with comparable rates of photic phenomena and spectacle independence [3]. A comparative study evaluating three IOL strategies — bilateral EDOF implantation, bilateral trifocal implantation, and blended implantation of EDOF plus bifocal IOL — found that the EDOF group achieved the best visual quality scores, while the trifocal group obtained the widest range of visual acuity [9]. The blended (mix-and-match) strategy emerged as a compromise, offering good functional near and distance vision with acceptable photic disturbance profiles.

3. Methodology

This study follows a narrative literature review design, focusing on peer-reviewed clinical trials, randomized controlled studies, prospective observational studies, and meta-analyses published between 2016 and 2026 evaluating next-generation intraocular lenses in cataract surgery. Searches were conducted in PubMed/MEDLINE, Embase, and Cochrane Library using the following Medical Subject Headings (MeSH) terms and free-text keywords: "extended depth of focus," "EDOF intraocular lens," "premium IOL," "cataract surgery," "visual acuity," "contrast sensitivity," "patient-reported outcomes," and "spectacle independence."

3.1 Eligibility Criteria

Studies were included if they: (a) enrolled adult patients (age ≥ 18 years) undergoing phacoemulsification cataract surgery with bilateral IOL implantation; (b) reported postoperative visual acuity outcomes at a minimum follow-up of three months; and (c) used validated instruments for patient-reported outcomes. Studies were excluded if they were limited to in vitro optical bench analyses, animal models, or had a follow-up period of less than one month. Case reports and non-peer-reviewed publications were also excluded.

3.2 Data Extraction and Analysis

Data were extracted on study design, sample size, IOL models evaluated, postoperative follow-up intervals, primary visual outcomes (distance, intermediate, and near uncorrected and corrected visual acuities expressed in logMAR), defocus curves, contrast sensitivity, incidence of photic phenomena (halos, glare), spectacle independence rates, and patient-reported outcome measures including the Catquest-9SF and the National Eye Institute Visual Function Questionnaire-25 (NEI VFQ-25). Given the narrative design, no formal meta-analytic pooling was performed beyond what was already reported by included systematic reviews.

4. Findings

The literature consistently demonstrates that EDOF IOLs offer a favorable balance between expanded visual range and optical quality when compared with conventional monofocal lenses. The evidence is organized below according to three key outcome domains: visual acuity across distances, optical quality and safety profile, and patient satisfaction.

4.1 Visual Acuity Outcomes

Clinical trials evaluating non-diffractive EDOF IOLs, such as the AcrySof® IQ Vivity™ (Alcon), have demonstrated robust intermediate and distance visual outcomes. At six months postoperatively, 95.45% of implanted eyes achieved a refractive cylinder of ≤0.50 D, with a mean manifest refraction spherical equivalent of -0.19 ± 0.20 D. Mean corrected distance visual acuity (CDVA), distance-corrected intermediate visual acuity (DCIVA), and distance-corrected near visual acuity (DCNVA) were 0.02 ±

0.08, 0.16 ± 0.11, and 0.26 ± 0.15 logMAR, respectively [10]. These results highlight the strong refractive predictability and functional intermediate vision achievable with non-diffractive platforms.

The ELON IOL (Medicontur Medical Engineering), a refractive EDOF lens based on central optical profile modification, achieved a defocus range of 1.7 D at a threshold of ≤0.2 logMAR — consistent with the Partial Range of Field Extended (PRoF-Ex) classification — and demonstrated visual acuity improvements over 12 months, with enhanced near vision in eyes with smaller pupils [11]. A randomized controlled multicenter trial of the xact Mono-EDOF ME4 IOL, conducted across sites in the United Kingdom, France, and Portugal, demonstrated significantly superior uncorrected intermediate visual acuity compared with a standard aspheric monofocal (TECNIS 1-Piece ZCB00) at 120–180 days postoperatively, without compromising contrast sensitivity or generating additional photic phenomena [12].

4.2 Optical Quality and Safety Profile

EDOF IOLs based on non-diffractive, wavefront-shaping technology — such as the Asqelio™ EDOF (ETLIO130C/ETPIO130C) — demonstrated binocular uncorrected distance, intermediate, and near visual acuities of 0.00 ± 0.09, 0.13 ± 0.12, and 0.32 ± 0.15 logMAR, respectively, at three months [13]. Contrast sensitivity and optical scatter index (OSI) values were comparable to those of a standard monofocal control group ($p > 0.05$), and higher-order aberrations were significantly lower in the EDOF group ($p < 0.001$). No adverse events were reported, reinforcing the favorable safety profile of this lens category.

A key comparative finding across studies is the trade-off between near vision performance and dysphotopsia rates. EDOF lenses consistently demonstrate lower incidences of bothersome halos and glare than trifocal diffractive designs, making them particularly suitable for patients with occupations or lifestyles that demand superior night vision, such as drivers and pilots. Table 1 summarizes the comparative visual outcomes across the main IOL categories reviewed in this study.

IOL Category	UDIVA[1] (logMAR)	UNVA[1] (logMAR)	Photic Phenomena	Spectacle Indep.
Monofocal	0.17–0.25	0.30–0.45	Low	Low
EDOF (diffractive)	0.11–0.17	0.22–0.30	Moderate	Moderate
EDOF(non-diffractive)	0.10–0.16	0.25–0.32	Low–Moderate	Moderate–High
Trifocal	0.07–0.14	0.08–0.18	High	High

Table 1: Comparative visual outcomes across intraocular lens categories in cataract surgery. UDIVA = uncorrected distance-corrected intermediate visual acuity; UNVA = uncorrected near visual acuity. Values represent approximate ranges derived from the reviewed literature. Source: Compiled from reviewed studies, 2019–2025.

4.3 Patient-Reported Outcomes and Satisfaction

Patient-reported outcome measures consistently favor EDOF IOLs over monofocal designs in domains related to functional vision at intermediate distances. Using the Catquest-9SF, patients implanted with EDOF IOLs reported fewer difficulties with activities such as reading price tags, working on computers, and recognizing faces in dim lighting [13]. The NEI VFQ-25 also demonstrated statistically significant improvements across multiple vision-targeted subscales after EDOF IOL implantation, particularly in near activities and driving [10].

A mix-and-match strategy — using an EDOF IOL in the dominant eye and a combined technology multifocal IOL in the nondominant eye — demonstrated additive benefits while mitigating the individual shortcomings of each lens type [14]. This approach was well-tolerated and resulted in favorable binocular visual acuity from distance to near, making it a viable option for patients who prioritize both visual quality and spectacle independence.

5. Conclusion and Recommendations

5.1 Conclusion

Next-generation EDOF intraocular lenses represent a meaningful advance in cataract surgery, offering patients an extended functional range of vision with a more favorable photic phenomena profile than conventional multifocal IOLs. The evidence reviewed herein demonstrates consistent advantages in uncorrected intermediate visual acuity and spectacle independence over monofocal lenses, alongside superior optical quality compared with trifocal diffractive platforms. Both diffractive and non-diffractive EDOF technologies have demonstrated robust safety profiles, with rare adverse events reported across multiple controlled studies and registries.

The evolution from the original echelette-based Symfony platform toward purely refractive, non-diffractive EDOF designs reflects ongoing optimization aimed at preserving contrast sensitivity while broadening the depth of field. Emerging evidence suggests that personalized IOL selection — informed by patient lifestyle, ocular anatomy, and visual demands — is the cornerstone of achieving high postoperative satisfaction.

5.2 Recommendations

Based on the current evidence, the following recommendations are proposed for clinicians selecting EDOF IOLs in cataract surgery: (a) preoperative patient counseling should address realistic expectations regarding residual spectacle use for fine near tasks; (b) patients with significant corneal surface disease, irregular astigmatism, or advanced macular pathology should be carefully screened, as these conditions may compromise EDOF IOL performance; (c) mix-and-match strategies combining EDOF and multifocal IOLs should be considered for patients who prioritize broad spectacle independence; and (d) future research should focus on long-term (>2 years) comparative trials, including quality-of-life instruments, to better characterize the durability of functional outcomes across EDOF platforms.

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