

DESIGN AND VISUAL OUTCOMES OF ENHANCED MONOFOCAL IOLS



A review of the literature.

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Cataracts are one of the leading causes of vision impairment and decreased quality of life globally.¹ Most patients undergoing cataract surgery receive a monofocal IOL² and wear spectacles for some tasks postoperatively.^{2,3} Many individuals elect to receive multifocal IOLs to reduce their dependence on spectacles, but they must be willing to accept trade-offs such as out-of-pocket costs, reduced optical performance in low-light environments, increased dysphotopsias, and decreased overall quality of vision.²⁻⁵ To address these issues, industry has developed enhanced monofocal lenses (also known as *monofocal-plus lenses*) that provide functional vision over a broad range of distances.

Because enhanced monofocal IOLs do not have a central diffractive optic, they are indistinguishable from standard monofocal IOLs on visual inspection,²⁻⁴ but the former have a unique aspheric anterior or posterior surface.² Enhanced monofocal IOLs are designed to provide patients with good uncorrected distance visual acuity (UDVA), good uncorrected intermediate visual acuity (UIVA), and better functional near vision than a conventional monofocal IOL can deliver without the compromised quality of vision associated with multifocal IOLs.^{2,4} When implanting enhanced monofocal IOLs, surgeons often target a plano result in the dominant eye and apply a myopic power-offset to the nondominant eye. Astigmatism can be addressed with arcuate incisions or a monofocal-plus toric IOL.^{2,4-8}

This article draws on original studies, case series/reports, randomized clinical trials, systematic reviews, meta-analyses, and commentaries to explore the design and clinical efficacy of currently available enhanced monofocal IOLs as well as candidate selection (Table).

TECNIS EYHANCE Design

The Tecnis Eyhance (model ICB00; Johnson & Johnson Vision) is a hydrophobic monofocal IOL with a modified 6-mm biconvex aspheric anterior surface.⁶⁻⁹ Depth of focus is increased through higher-order asphericity, which creates a continuous expansion in dioptric power from the periphery to the center of the lens.⁶⁻⁸ Like the Tecnis Monofocal 1-Piece IOL (model ZCB00; Johnson & Johnson Vision), the Eyhance has negative spherical aberration (SA) in the periphery, but +0.50 D of additional power present in its central 2-mm zone induces a myopic shift to improve the patient's intermediate vision.⁹⁻¹³

Compared to the standard Tecnis Monofocal, the Tecnis Eyhance has been found to provide patients with 1 more line of monocular and binocular corrected intermediate visual acuity, corrected near visual acuity, and uncorrected near visual acuity.^{3,8,13-19} In several studies,^{3,8,13-18,20-26} patients who received an Eyhance in both eyes achieved good UIVA and total spectacle independence with no increase in dysphotopsias, halo, or glare or decrease in contrast sensitivity.

Although the Eyhance was not designed to provide reading vision, the IOL's central defocus can give patients a high degree of spectacle independence.^{13,15-21,27}

Candidate Selection

Falling on the spectrum between premium and conventional monofocal IOLs, the Tecnis Eyhance benefits patients who desire improved UIVA and UDVA with the added benefit of astigmatism correction. This IOL may be a poor choice for patients who have irregular astigmatism and those who have undergone hyperopic LASIK because it increases the negative SA already present in their eyes, potentially compromising their quality of vision.^{19,20,22-27}

RAYONE EMV Design

The RayOne EMV IOL (Rayner) is a hydrophilic lens with positive SA in the optic center that increases patients' range of focus.²⁸ This lens was optimized to provide mini-monovision to patients who have between 0.50 and 1.50 D of anisometropia, with the nondominant eye targeted for distance vision.^{28,29} The EMV features a blended edge that reduces longitudinal SA toward the periphery to maintain contrast sensitivity under mesopic conditions.^{23,24,28,29} The lens provides up to +1.25 D of extended visual range when bilateral emmetropia is targeted.^{26,30,31} The inner portion of the IOL has positive SA to enhance depth of focus and distance

vision in the nondominant eye while the lens periphery maintains neutral aberration.²⁴⁻²⁶ The EMV's haptics are designed to prevent excessive lens decentration, allowing an average offset maximum of 0.08 mm that can otherwise induce higher-order aberrations that may diminish image quality.^{24-26,28,29,32}

Candidate Selection

Suitable candidates for the RayOne EMV IOL include patients who have less than 1.50 D of corneal astigmatism preoperatively, individuals who are not candidates for diffractive trifocal IOLs, patients with up to 0.35 μm of positive corneal SA, those who have a history of hyperopic LASIK, and those with a high angle alpha or kappa.^{26,28,29,32} To achieve the best possible outcome, the dominant eye should be targeted for plano because the lens' positive SA induces a myopic shift.

Because of its central positive SA, the EMV may be a poor choice for patients who have a history of myopic LASIK. Because the modulation transfer function of the EMV decreases with large pupils, meticulous biometric measurements (including scotopic pupil size) should be obtained before implantation. The IOL is contraindicated for individuals who have large pupils, severe ocular surface disease, high regular astigmatism, a history of myopic excimer laser ablation, or irregular astigmatism. It should also be avoided in patients who may need intraocular gas in the future (eg, those with Fuchs dystrophy and retinal tears) because the hydrophobic acrylic lens material may calcify after exposure to gas.^{23-26,28,29}

ENVISTA ASPIRE Design

The enVista Aspire (model MX60E/PL; Bausch + Lomb) is a hydrophobic IOL³³⁻³⁵ with a higher-order posterior aspheric surface designed to increase power within the central 1.5-mm diameter to achieve 1.25 D of depth of focus.^{35,36} Notable postoperative

endpoints include a well-established safety profile, predictable visual outcomes comparable to those of other enhanced monofocal IOLs, stable refractive outcomes, no reports of glistenings, and a low incidence of Nd:YAG laser capsulotomies.³³⁻³⁷

Candidate Selection

As little as +0.50 D of astigmatism can cause visual disturbances, and approximately 73% of cataract surgery patients have 1.25 D of astigmatism or less.^{1,37} Because the enVista is available in a low-cylinder toric model (+1.25 D of cylinder at the lens plane and 0.83 D of correction at the corneal plane), it is an option for the treatment of patients with low astigmatism. Moreover, the IOL's availability in multiple toric steps at 0.50 D intervals allows more precise control of astigmatism than other toric lenses, which generally have 0.75 D astigmatic steps.³⁴⁻³⁹

The enVista lens is an option for patients who desire as much independence from spectacles as possible and are not candidates for a presbyopia-correcting IOL. When a modified monovision strategy is employed, the enVista can provide patients with good UDVA and uncorrected near visual acuity. Thanks to its aberration-free design, the IOL may be considered for patients with a history of refractive surgery who have aberrated corneas.^{33,34}

The major contraindications for the enVista are recurrent severe inflammation of the anterior or posterior segment, uncontrolled glaucoma, and a compromised posterior capsule or zonules that are unable to support the IOL properly upon implantation.^{33,34}

CT LUCIA Design

The CT LUCIA (model 621P; Carl Zeiss Meditec) is a hydrophobic, heparin-coated acrylic lens that is available in a broad range of powers (+0.00 to +34.00 D in 0.50 D steps) and an A constant of 120.2.⁴⁰ The IOL has

a nonconstant aberration profile that features a central zone with negative SA that positively changes toward the periphery to create a near-neutral effect and improve its tolerance of decentration, even in patients with pupils larger than 3.5 mm.^{12,41-45} Of 191 eyes that received a CT LUCIA 621P, 84.8% and 98.4% achieved an early clinical outcome that was within +0.50 D and 1.00 D of emmetropia, respectively, and no eye had an outcome that was more than +1.125 D from emmetropia.^{44,45}

Candidate Selection

Patients who have some positive corneal SA, either due to age or previous myopic LASIK, can benefit from the CT LUCIA. A three-piece model of the lens features polyvinylidene fluoride monofilament haptics that provide increased strength and flexibility^{40,45}—ideal for intrascleral haptic fixation of the lens. Candidates for this IOL therefore include patients for whom the Yamane technique is required.^{41,46}

Patients who have a history of hyperopic LASIK are poor candidates for this IOL because it could increase negative SA.

IPURE Design

The IPure (model B1PC; BVI) is a clear, one-piece, hydrophobic, UV-filtered acrylic IOL with a double C-loop haptic design. The lens is available in powers ranging from +6.00 to +30.00 D in 0.50 D increments and an A constant of 118.4.⁴⁷⁻⁴⁹ A blue light-blocking, yellow-colored model (B1PY) is also available.⁵⁰

The three-zone aspheric optic design has neutral SA in the 2.4-mm central optic (zones 1 and 2) and -0.18 μm of SA in the periphery (zone 3).⁵⁰ This design offers high contrast under various lighting conditions, maintains natural corneal depth of focus, and exhibits less contrast sensitivity degradation due to natural off-axis conditions, lens decentration, or corneal aberrations compared to other IOLs.⁴⁸⁻⁵¹

TABLE. COMPARATIVE SPECIFICATIONS OF ENHANCED MONOFOCAL IOLS

IOL	Manufacturer	Material	Central Zone (SA)	Periphery (SA)	Strong Candidates	Questionable Candidates	Range of Focus	Dioptic Range	Toric Steps (D)
CT-Lucia P	Carl Zeiss Meditec	Hydrophobic acrylic	-0.24 μm	Slightly negative (-0.08 μm)	Patients who have a history of myopic LASIK or a long axial length	Patients who have a history of hyperopic LASIK	0.75 D	0-34.00	N/A
enVista Aspire	Bausch + Lomb	Hydrophobic acrylic	-0.02 μm	Neutral	Broad range	Patients with uveitis or absent zonules	1.25 D	6.00-34.00	1.25, 1.50, 2.00, 2.50, 3.00, 3.50, 4.25, 5.00, 5.75
IPure B1PC/B1PY	BVI	Hydrophobic acrylic	Neutral	-0.18 μm	Patients with keratoconus, those who have a history of hyperopic LASIK, and those who would benefit from a yellow optic	Patients with small pupils	0.75 D	6.00-30.00	N/A
Rayner EMV	Rayner	Hydrophilic acrylic	+0.15 μm	Neutral	Patients who have a history of hyperopic LASIK	Patients with large pupils or a history of myopic LASIK	1.25 D	10.00-30.00	N/A
Tecnis Eyhance	Johnson & Johnson Vision	Hydrophobic acrylic	Near neutral	-0.27 μm	Patients who have a history of radial keratotomy	Patients who have a history of myopic LASIK	0.75 D	5.00-34.00	1.50, 2.25, 3.00, 3.75, 4.50, 5.25, 6.00

Abbreviation: SA, spherical aberration.

Published data on patients' visual acuity and refractive outcomes with the B1PC are limited. When a plano result is targeted, patients can achieve good UIVA, but most recipients of the lens have needed spectacles for intermediate and near vision.⁵⁰

Candidate Selection

Ideal candidates for the IPure IOL have normal (0.25–0.35 μm) positive corneal SA. This lens can also be useful for patients who have keratoconus or a history of LASIK.

Poor candidates for the IPure include patients who have small pupils. The IOL's optical system offers the greatest optical corneal SA neutralization and reduction in corneal functional power to eyes with large dilated pupils.⁴⁷⁻⁵¹

CONCLUSION

Two other IOLs are worth noting here. The first is the Light Adjustable Lens+ (RxSight). This silicone IOL has a central add power that can be adjusted postoperatively to achieve negative SA,

potentially providing up to 1.60 D of depth of focus.^{52,53} The second is the Clareon Monofocal IOL (Alcon), which has -0.2 μm of SA across the entire optic. This lens seems to provide about -0.62 D of depth of focus with a refractive target of plano.⁵⁴ No SA differences between the central and peripheral zones have been reported with either of these IOLs.^{53,54}

Low amounts of SA can increase depth of focus. Because data show that SA can also improve quality of vision, industry has developed and released aspheric IOLs.^{3,9,52} Many cataract surgeons implant IOLs with negative SA to neutralize the positive SA commonly found in patients' eyes.

The facility cost of enhanced monofocal IOLs is somewhat higher than that of a standard monofocal IOL, but the former are a safe and clinically proven alternative that offers patients better UIVA and lower power requirements without significant visual compromise by lowering the modulation transfer function while maintaining visual quality and enhancing quality of

life. Compared to extended depth of focus and multifocal IOLs, enhanced monofocal IOLs may allow physicians to place less emphasis on pupillary diameter and the patient's personality, tolerance for photic phenomena, and preferred reading distance. The pool of candidates for enhanced monofocal lenses is wide, including patients with positive corneal SA and those aiming for excellent UDVA and UIVA. This IOL category is a boon to surgeons and patients alike. ■

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