

Optical-Bench Characterization of Halo Phenomena in Trifocal Intraocular Lenses

A Comparative In Vitro Assessment of enVista Envoy™, Clareon® PanOptix®, and Tecnis Odyssey™ IOLs

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EXECUTIVE SUMMARY

Cataract surgery involves replacing the clouded natural lens with an artificial intraocular lens (IOL).

Modern IOL designs, like Full Visual Range (FVR) lenses, are designed to increase spectacle independence across various distances but can result in visual disturbances—notably halos around bright lights at night.

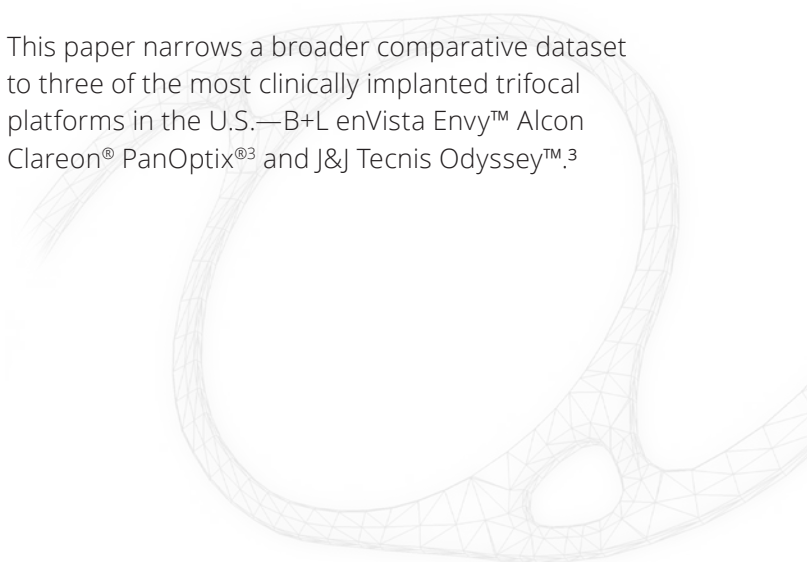
Halos negatively impact visual comfort and quality of vision, making their minimization a critical aspect of IOL design and selection. This white paper provides a focused synthesis of optical-bench data characterizing halo phenomena associated with trifocal intraocular lenses. This document describes mechanistic optical behavior under standardized in-vitro conditions. Findings are presented within appropriate evidentiary boundaries and are not intended to predict individual patient experience.

Background and Rationale

Halos are a clinically relevant photic phenomenon associated with presbyopia-correcting IOL designs, particularly under mesopic or night-time viewing conditions. Optical-bench testing enables controlled and repeatable assessment of halo formation by isolating optical contributors such as diffractive energy distribution, add power, apodization, and pupil dependence.^{1,2}

The clinical relevance of halos extends beyond subjective annoyance: persistent or severe photic disturbances are among the leading causes of patient dissatisfaction following premium IOL implantation and can necessitate IOL exchange. Preoperative counseling therefore benefits from objective, quantifiable in vitro data that characterize and differentiate halo behavior across competing lens platforms.

This paper narrows a broader comparative dataset to three of the most clinically implanted trifocal platforms in the U.S.—B+L enVista Envoy™ Alcon Clareon® PanOptix®³ and J&J Tecnis Odyssey™.³



Methods Overview

Optical-bench testing was conducted on an artificial-eye model with spherical aberration +0.27 μm at a 5.15 mm IOL-plane pupil, warm-white LED illumination (3000 K), and digital image acquisition with sensitivity following the photopic spectral efficiency to approximate human visual sensitivity, all IOLs were 20D base power. Testing followed the recommendations of ANSI Z80.35-2018 and ISO 11979-2:2024 standards for optical-bench assessment of intraocular lenses.^{4,5} A pinhole subtending 3.44 arcmin in diameter was used to simulate halo/glare conditions. These angular dimensions are visually equivalent to approximately observing a 20 cm car headlight at 200 m. For better visualization, the images are shown in logarithmic scale.

The lenses evaluated in this study were:

- enVista Envy™ (Bausch + Lomb): Apodized diffractive FVR IOL. The apodization gradient progressively attenuates diffractive step height from center to periphery, reducing the amount of energy in the intermediate and near foci at larger pupils.
- Tecnis Odyssey™ (Johnson & Johnson Vision): Non-apodized trifocal diffractive IOL with chromatic aberration correction at the distance focus.
- Clareon® PanOptix® (Alcon): Non-apodized trifocal diffractive IOL with uniform diffractive profile across the full optic zone.

Halo images in far vision were acquired at two aperture sizes—3.0 mm and 4.5 mm at the IOL plane—representing photopic and mesopic pupil conditions, respectively. Halo diameter was quantified as the angular subtense (arcmin) derived from the radial intensity profiles averaged across vertical and horizontal meridians.

Key Findings

Figure 1 shows logarithmic halo images in far vision for the three IOLs at 3.0 mm and 4.5 mm pupil sizes (top and middle rows), together with the corresponding mean intensity profiles averaged across the vertical and horizontal meridians (bottom row). At the 3.0 mm pupil, all three lenses exhibited a broadly similar halo diameter (approximately 20 arcmin). At the 4.5 mm pupil, however, differences became more apparent: enVista Envy showed a smaller halo diameter than PanOptix and Odyssey. In addition, Envy demonstrated minimal change in halo diameter between the two pupil sizes, whereas both PanOptix and Odyssey showed an increase in halo diameter with the larger pupil—an effect that was particularly pronounced for PanOptix.

Halo Size and Pupil Dependence

- Meaningful divergence between platforms emerged at the 4.5 mm aperture (mesopic conditions):
- enVista Envy™: Halo diameter remained essentially unchanged from 3.0 mm to 4.5 mm pupil (~20 arcmin at both apertures; size increase within experimental uncertainty of 0.5 arcmin, <1%). The apodized design effectively curtailed energy spread at the larger pupil, yielding a smooth, uniform luminous ring of stable size.
 - Clareon® PanOptix®: Halo diameter increased substantially from ~21 arcmin (3.0 mm) to ~30 arcmin (4.5 mm)—an increase of approximately 9 arcmin (+43%)—the largest absolute and relative growth among the three platforms. The halo became progressively more diffuse at the mesopic pupil.
 - Tecnis Odyssey™: Halo diameter showed a moderate increase from ~20 arcmin (3.0 mm) to ~24 arcmin (4.5 mm) (+4 arcmin, +20%). Although intermediate between Envy and PanOptix, the Odyssey halo was single-ringed and showed meaningful pupil dependence compared to Envy.

IOL	3.0 mm Pupil (~ arcmin)	4.5 mm Pupil (~ arcmin)	Size Increase (arcmin / %)
enVista Envy™ (B+L)	~20	~20	+0 / <1%
Clareon® PanOptix® (Alcon)	~21	~30	+9 / +43%
Tecnis Odyssey™ (J&J)	~20	~24	+4 / +20%

Table 1. Halo Size Summary (estimated from optical-bench radial intensity profiles)

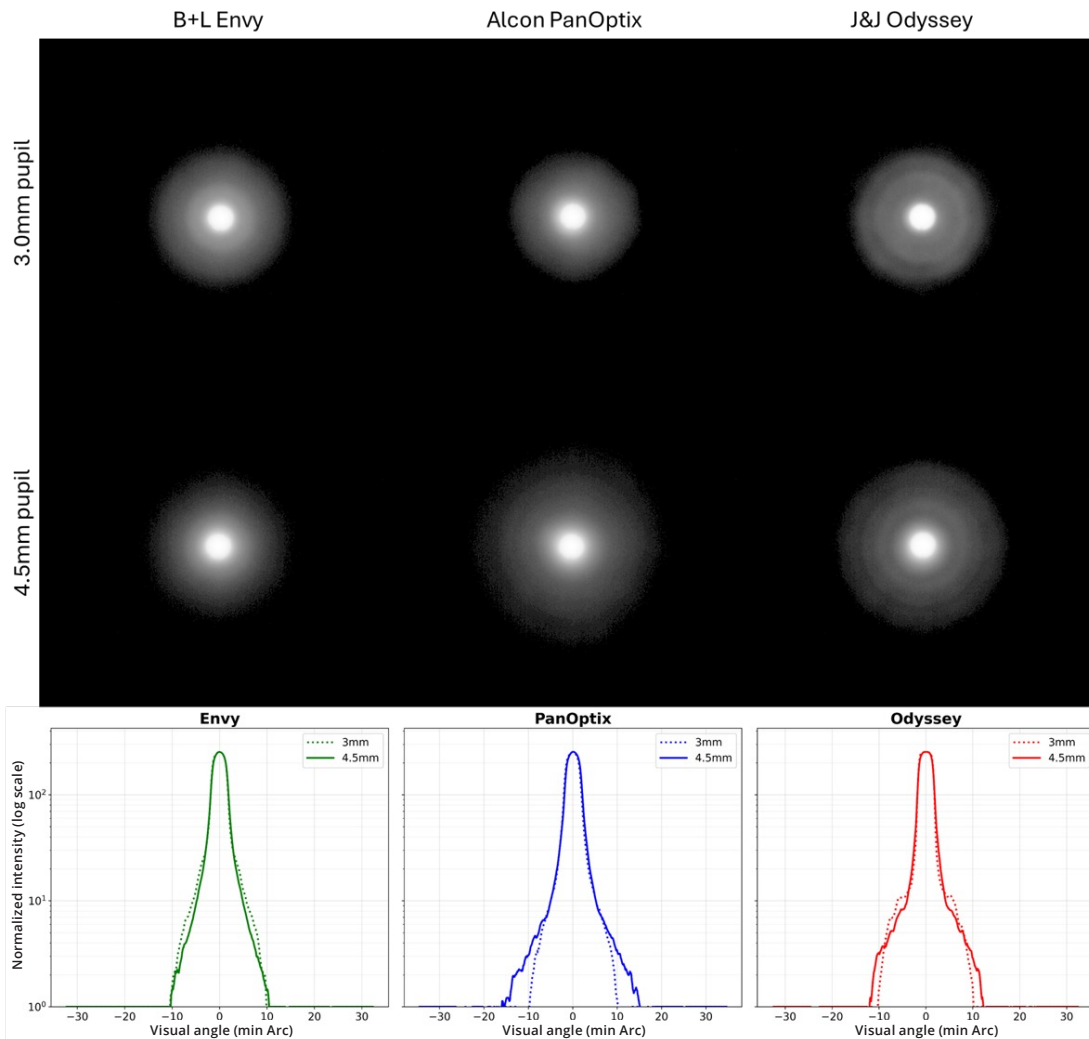


Figure 1. Optical-bench halo visualization and radial intensity profiles

Halo images obtained under standardized optical-bench conditions with corresponding radial intensity profiles. Images are displayed on a logarithmic intensity scale to facilitate visualization of halo structure. Profiles represent the mean intensity averaged across the vertical and horizontal meridians; dotted lines = 3.0 mm pupil, solid lines = 4.5 mm pupil.

Interpretation

These findings illustrate design-dependent optical behavior of trifocal IOLs under controlled laboratory conditions. Optical-bench data provide mechanistic insight and should be interpreted as complementary to clinical and patient-reported outcomes.

The findings support several evidence-aligned messages:

- **Trifocal trade-offs:** The presence of multiple focal points is associated with broader halo phenomena under controlled optical-bench conditions. All three platforms exhibited this effect, with magnitude varying by design.
- **Apodization advantage:** The Envy apodized design uniquely constrains halo size across pupil diameters. Under mesopic conditions, PanOptix halo diameter grew by ~43% and Odyssey by ~20%, while the size increase falls within the experimental uncertainty—a direct consequence of the apodization.
- **Pupil dependence:** Larger pupils, representative of mesopic conditions, accentuate halo visibility in non-apodized trifocal models. This is particularly pronounced for PanOptix.
- **Appropriate use of bench data:** Optical-bench findings provide objective insight and should be positioned as complementary to clinical and patient-reported outcomes rather than predictive of individual patient experience.

Limitations

As an in-vitro assessment, data are derived from an optical-bench model eye and therefore this analysis does not account for neuroadaptation or subjective perception. Findings should be considered within the methodological constraints of laboratory testing. Additional limitations include:

- Model eye conditions approximate but do not replicate the full complexity of the human optical system (higher-order aberrations, scatter, media opacity).
- Testing was conducted at a single nominal lens power (+20.0 D); halo characteristics may vary across the clinical power range.
- Halo size values in Table 1 are estimated from radial intensity profiles; exact threshold-based measurements may differ marginally.
- Subjective perception of halo size and annoyance is multifactorial and cannot be directly inferred from angular measurements alone.

Conclusion

The halo of the FVR enVista Envy™ IOL was analyzed and compared to two other trifocal diffractive IOLs. With light conditions emulating mesopic vision, the new FVR IOL produces smaller and smoother halos than PanOptix™ and Odyssey™ respectively. At the mesopic pupil, PanOptix halo diameter increased by ~43% and Odyssey by ~20%, while Envy showed no measurable change—a consequence of its specific apodized diffractive architecture. Clinical studies are necessary to assess the influence of these findings on the visual comfort and quality of life of patients implanted with the new FVR enVista Envy™ IOL.

A focused, within-class optical-bench assessment using standardized methodologies supports high-quality scientific exchange and medical education among ophthalmic surgeons.

References

1. Vega F, Alba-Bueno F, Millán MS, et al. Halo and through-focus performance of four diffractive multifocal intraocular lenses. *Invest Ophthalmol Vis Sci*. 2015;56:3967–3975.
2. Alba-Bueno F, Vega F, Millán MS. Halos and multifocal intraocular lenses: origin and interpretation. *Arch Soc Esp Oftalmol*. 2014;89:397–404.
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4. ANSI Z80.35-2018. Ophthalmics — Intraocular lenses. American National Standards Institute; 2018.
5. ISO 11979-2:2014. Ophthalmic implants — Intraocular lenses — Part 2: Optical properties and test methods. International Organization for Standardization; 2014.

This document is intended for educational and scientific exchange among ophthalmic surgeons. Optical-bench findings do not constitute clinical evidence and are not intended to predict individual patient outcomes. enVista Envy™ is a trademark of Bausch & Lomb. PanOptix® is a registered trademark of Alcon. Tecnis Odyssey™ is a trademark of Johnson & Johnson Vision. Data derived from: Vega et al., ARVO 2025 (Abstract 4256600). Study supported by Agencia Estatal de Investigación, Spain (PID2020-114582RB-I00) and Bausch + Lomb.

ENVISTA ENVY™ TORIC AND NON-TORIC IOL INDICATIONS AND IMPORTANT SAFETY INFORMATION

INDICATIONS

The **enVista Envy™ hydrophobic acrylic IOL** is indicated for primary implantation in the capsular bag of the eye in adult patients for visual correction of aphakia with less than or equal to 1.0 D preoperative corneal astigmatism following removal of a cataractous lens to mitigate the effects of presbyopia by providing improved intermediate and near visual acuity, while maintaining comparable distance visual acuity to an aspheric monofocal IOL.

The **enVista Envy™ toric hydrophobic acrylic IOL** is indicated for primary implantation in the capsular bag of the eye in adult patients for visual correction of aphakia and corneal astigmatism following removal of a cataractous lens to mitigate the effects of presbyopia by providing improved intermediate and near visual acuity, while maintaining comparable distance visual acuity to an aspheric monofocal IOL.

WARNINGS/PRECAUTIONS

Physicians should weigh the potential risk/benefit ratio before implanting the enVista Envy™ lens under any of the circumstances or conditions outlined in the Instructions for Use labeling. Some visual disturbances may be expected due to the superposition of focused and unfocused multiple images. These may include some perceptions of halos or radial lines around point sources of light (starbursts) under nighttime conditions, glare, double vision, haziness and blurred vision. It is expected that, in a small percentage of patients, the observation of such phenomena will be annoying and may be perceived as a hindrance, particularly in low illumination conditions such as nighttime driving. As with other trifocal IOLs, there is a possibility that visual disturbances may be significant enough that the patient will request explant of the IOL. A reduction in contrast sensitivity as compared to a monofocal IOL may be experienced by some patients, therefore, patients implanted with trifocal IOLs should exercise caution when driving at night or in low light or poor visibility conditions. Care should be taken to achieve IOL centration as IOL decentration may result in patients experiencing visual disturbances or suboptimal vision under certain lighting conditions. The surgeon must target emmetropia to achieve optimal visual performance. Patients should be advised that unexpected outcomes could lead to continued spectacle dependence or the need for secondary surgical intervention (e.g., intraocular lens replacement or repositioning). Please provide a copy of the Patient Information Brochure, which can be found at www.bausch.com/IFU. Posterior capsule opacification (PCO) may significantly affect the vision of patients with multifocal IOLs earlier in its progression than patients with monofocal IOLs. This may be due to the reduced contrast sensitivity observed with multifocal IOLs.

ADDITIONAL PRECAUTIONS FOR TORIC IOLS: The enVista Envy™ Toric IOL has not been evaluated in a clinical study. In general, astigmatism that is corrected with a higher cylinder power IOL can result in clinically significant residual astigmatism. The effect of residual astigmatism at distance, intermediate, and near was evaluated in a clinical study of patients who had been implanted with non-toric enVista Envy™ IOLs and were induced with cylinder power to simulate various levels of residual astigmatism. If a secondary surgical intervention is necessary to reposition the IOL, explantation should be considered as some patients may have recurrent or persistent issues related to rotational instability and misalignment.

CAUTION: Federal law restricts this device to sale by or on the order of a physician.

ATTENTION: See the Directions for Use for a complete listing of indications and important safety information.

For more information on safety and directions for use, please visit <https://www.bausch.com/ifu>

