

A Retrospective Study: Comparative Visual Performance of Two Non-Diffractive Extended Depth-of-Focus Intraocular Lenses: TECNIS PureSee versus Clareon Vivity

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Purpose: To compare postoperative visual performance between two non-diffractive, extended depth-of-focus (EDoF) intraocular lenses (IOLs) — TECNIS PureSee and Clareon Vivity — by evaluating visual acuity, contrast sensitivity, and patient-reported outcomes.

Methods: In this retrospective comparative study, 102 eyes (51 per group) received either the PureSee or Vivity IOL. Visual acuity at various distances, defocus curves, and contrast sensitivity under photopic and mesopic conditions were assessed at 2 months postoperatively. Patient satisfaction and visual disturbances were also evaluated.

Results: Both the PureSee and Vivity IOL demonstrated comparable visual acuity at far and near distances, while the Vivity showing significantly better visual acuity at intermediate distances ($P = 0.045$). Contrast sensitivity was significantly higher in the PureSee group at higher spatial frequencies ($P = 0.038$). Patient satisfaction and spectacle independence were high and comparable in both groups. The Vivity group showed a trend toward fewer reports of glare and halo.

Conclusion: The Vivity IOL performed better at intermediate distances with fewer photic phenomena when compared with the PureSee IOL. The differences between these two EDoF IOLs may help in lens selection based on patient's visual demands and lifestyle.

Keywords: extended depth-of-focus IOLs, cataract surgery, TECNIS PureSee, Clareon Vivity

Introduction

With a growing emphasis on spectacle independence and improving visual acuity without compromising visual quality, the evolution of intraocular lens (IOL) technology has significantly transformed cataract and refractive lens exchange surgery.^{1–3} In response, extended depth-of-focus (EDoF) IOLs have emerged as a competitive alternative, offering a continuous range of focus with a single elongated focal point.^{4,5} EDoF IOLs aim to find a balance between monofocal and multifocal lenses, enhancing intermediate and functional near vision while preserving distance acuity and minimising dysphotopsia.^{4,5}

A large number of lenses claiming EDoF capabilities have entered the market.⁵ To establish a clear definition, the American Academy of Ophthalmology (AAO) and the FDA have developed formal criteria, published in the ANSI Z80.38–2018 standard.⁶ According to this, an EDoF IOL must have a continuous optical profile, deliver better

intermediate vision than monofocal lenses, and preserve monofocal-like distance vision with minimal visual disturbances.^{5–7} EDoF IOLs can be classified into five categories based on their underlying optical mechanisms: spherical aberration (SA)-based, small aperture, low-add multifocal lenses, hybrid EDoF–multifocal, and wavefront-shaping IOLs.^{5,7} Among these, wavefront-shaping IOLs are a newer class that reshapes light wavefronts via a customised optical geometry to create a continuous range of focus. These IOLs can provide extended range vision while maintaining high contrast sensitivity and a low dysphotopsia profile.^{5,7,8}

Both the TECNIS PureSee (Johnson & Johnson Vision, CA, USA) and Clareon Vivity (Alcon Laboratories, TX, USA) IOLs are non-diffractive EDoF IOLs engineered to provide extended vision while maintaining monofocal-like contrast sensitivity and minimising photic phenomena.^{2,4,5} Although both rely on wavefront modulation, their designs differ in that the PureSee IOL uses specially engineered anterior and posterior surfaces to induce controlled spherical aberration, while the Vivity IOL incorporates wavefront-shaping within the central optical zone.^{9–12} PureSee IOL is designed to provide a continuous change in power through spherical aberration distributed longitudinally across focal point.^{7,13,14} This aims to deliver uninterrupted vision at different distances while preserving better contrast sensitivity.^{14,15} Clinically, PureSee IOL has demonstrated excellent distance and intermediate vision with some functional near acuity, as well as greater tolerance to residual refractive error and high levels of patient satisfaction.^{9,16} Regarding the Vivity IOL, central wavefront stretching reshapes the central portion of the optic to produce a smooth and continuous defocus curve, which may reduce abrupt changes in image quality and improve functional vision at intermediate distances.^{7,13,15} While clinical studies on Clareon Vivity are currently limited, it is expected to offer comparable distance and intermediate vision, with reduced incidence of halos and glare.

Although several studies have evaluated the individual performance of EDoF lenses, no comparative data currently exist between the PureSee and Clareon Vivity IOLs. Therefore, the aims of this study are to assess and compare postoperative outcomes, including visual acuity at various distances and contrast sensitivity two months after uneventful cataract surgery.

Methods

Study Design

This retrospective study adhered to the principles outlined in the Declaration of Helsinki and received approval from the institutional review board of Asan Medical Center, Seoul, South Korea (IRB No. 2025–0925). Due to the retrospective nature of the study, the requirement for written informed consent was waived. All patient data were handled in accordance with applicable regulations to ensure patient confidentiality. Medical records of patients who underwent cataract surgery with implantation of either the TECNIS PureSee or Clareon Vivity IOL between July 2024 and April 2025 at a single tertiary hospital in South Korea were reviewed.

Patient Selection Criteria

Patients aged over 60 years, who were diagnosed with cataracts and underwent standard phacoemulsification, were included in this study. To avoid inter-eye correlation, only one eye per patient was included in the analysis. Exclusion criteria included a history of previous ocular surgery or trauma, irregular corneal astigmatism, or any ocular pathology (eg., glaucoma, uveitis, retinal disease) that could affect postoperative visual outcomes.

Assessments

Patients underwent comprehensive ophthalmologic examinations before surgery. Slit-lamp biomicroscopy was performed to assess cataract severity using the Lens Opacities Classification System III (LOCS III).¹⁷ Keratometry (K) was measured using an auto-kerato-refractometer (KR-800; Topcon, Tokyo, Japan), and intraocular pressure was assessed with a non-contact tonometer (CT-80A; Topcon). Biometric parameters such as axial length (AL), anterior chamber depth (ACD), lens thickness (LT), and white-to-white (WTW) were measured using the IOLMaster 700 (Carl Zeiss Meditec, Jena, Germany), and corneal tomography was evaluated with CASIA2 (Tomey Corporation, Nagoya, Japan). Retinal and optic nerve evaluations were conducted after pharmacologic mydriasis. Postoperative uncorrected and corrected distance

visual acuity (UDVA, CDVA), uncorrected intermediate visual acuity (UIVA), uncorrected near visual acuity (UNVA) were assessed two months after surgery using a standardized logMAR chart (ETDRS; Precision Vision, USA). Manifest refraction at 6 m distance and contrast sensitivity under photopic and mesopic conditions were also evaluated.

Questionnaire Design

A 5-point Likert scale questionnaire was adapted from the Refractive Cataract Surgery Survey (RCSS) to assess patient satisfaction, dependence on near glasses, and photic phenomena (glare and haloes).¹⁸ The questionnaire was modified to assess satisfaction with both the IOL and the procedure by asking whether patients would recommend their chosen IOL.

Surgical Technique

All surgeries were performed by three experienced surgeons under topical anaesthesia using the Centurion Vision System (Alcon Laboratories). A 2.2mm temporal clear corneal incision was made, followed by continuous curvilinear capsulorhexis of approximately 5.0 mm. After standard phacoemulsification, the selected IOL was implanted in the capsular bag. The target postoperative refraction was emmetropia in both groups. IOL power calculations were performed based on four formulas (Barrett Universal II, SRK/T, Haigis, and Holladay 2) from the IOLMaster 700 and seven formulas (Barrett Universal II, Cooke K6, EVO 2.0, Hill-RBF 3.0, Hoffer QST, Kane, and PEARL-DGS) from the ESCRS IOL calculator. The median predicted IOL power achieving emmetropia was used as the target for implantation to minimize formula-specific bias. Stromal hydration was applied to seal all incisions. Postoperatively, patients received a combination of 1.0% prednisolone acetate (Pred Forte; Allergan) and 0.5% levofloxacin (Cravit 1.5%; Santen) for 4 weeks.

Statistical Analysis

Statistical analyses were conducted using R studio (version 2024.12.0; Posit Software, PBC, Boston, MA, USA). The Shapiro–Wilk test was applied to evaluate the normality of continuous variables. Depending on the distribution, either independent *t*-tests or Mann–Whitney *U*-tests were used for comparison. Categorical variables were analyzed using either the chi-square test or Fisher’s exact test, as appropriate. A *P*-value less than 0.05 was considered statistically significant.

Results

A total of 102 eyes were included in this study, with 51 eyes in the PureSee group and 51 eyes in the Vivity group. There were no significant differences between the two groups in terms of age, sex, or laterality (Table 1). Preoperative spherical equivalent was more myopic in the Vivity group ($P = 0.049$), while other baseline characteristics, including K, AL, ACD, and CCT, were comparable between the two groups.

Postoperative visual acuity outcomes are summarized in Table 2 and Figure 1. There were no statistically significant differences in distance visual acuity between the groups (UDVA: 0.12 ± 0.13 for the Vivity group vs 0.10 ± 0.12 for the PureSee group, $P = 0.282$; CDVA: 0.05 ± 0.06 for the Vivity group vs 0.04 ± 0.06 for the PureSee group, $P = 0.504$). Intermediate visual acuity at 66cm was significantly better in the Vivity group (0.16 ± 0.12 for the Vivity group vs 0.21 ± 0.14 for the PureSee group, $P = 0.045$), whereas near visual acuity was comparable between groups (0.40 ± 0.21 for the Vivity group vs 0.43 ± 0.22 for the PureSee group, $P = 0.652$). These results suggest that while overall visual performance was similar, the Vivity group offered a significant advantage at intermediate distances.

Cumulative Snellen visual acuity distributions showed that over 90.0% eyes in both groups achieved UDVA and CDVA of 20/40 or better (Figure 2). For intermediate vision, the Vivity group demonstrated higher proportions of eyes reaching each Snellen level compared to the PureSee group, with nearly 90.0% achieving 20/40 or better. In near vision, both groups showed lower rates overall, but Vivity yielded a slightly greater percentage of eyes achieving 20/40.

Uncorrected unilateral defocus curves were generated for both groups covering a range from +0.5 D to –4.0 D (Figure 3). Although the UDVA at 6 meters was comparable between groups, the PureSee group demonstrated significantly better visual acuity at +0.5D on the defocus curve ($P = 0.027$), while the Vivity group exhibited superior intermediate performance at –1.5D ($P = 0.045$). At near distances, the PureSee IOL showed a slight advantage, though

Table 1 Baseline Patient Characteristics

Parameter	Vivity (n = 51)	PureSee (n = 51)	P value
Age (years)	69.59 ± 6.08 (55–83)	69.14 ± 5.33 (60–82)	0.691
Laterality (OD/OS)	28 (54.9%) / 23 (45.1%)	32 (62.7%) / 19 (37.3%)	0.546
Sex (Male/Female)	15 (29.4%) / 36 (70.6%)	14 (27.5%) / 37 (72.5%)	1.000
UDVA (logMAR)	0.44 ± 0.28 (0.15–1.52)	0.35 ± 0.25 (0.10–1.52)	0.081
CDVA (logMAR)	0.22 ± 0.17 (0.00–0.70)	0.19 ± 0.19 (0.00–1.00)	0.142
IOP (mmHg)	17.04 ± 2.11 (11–21)	16.39 ± 2.43 (12–21)	0.154
SE (D)	−0.40 ± 2.34 (−6.25–5.75)	0.24 ± 2.04 (−7.25–2.75)	0.049
ARK_K1 (D)	44.03 ± 1.16 (41.25–46.50)	43.85 ± 1.39 (41.50–47.00)	0.465
ARK_K2 (D)	44.89 ± 1.14 (42.75–47.50)	44.48 ± 1.43 (42.25–47.50)	0.110
AL (mm)	23.73 ± 1.07 (21.85–27.51)	23.52 ± 1.06 (21.74–27.45)	0.311
IOLm_K1 (D)	44.00 ± 1.21 (4.072–46.53)	43.75 ± 1.42 (41.42–47.20)	0.339
IOLm_K2 (D)	44.84 ± 1.11 (42.84–47.31)	44.48 ± 1.48 (41.99–47.90)	0.163
ACD (mm)	3.13 ± 0.37 (2.28–4.16)	3.08 ± 0.40 (2.06–4.07)	0.536
LT (mm)	4.53 ± 0.43 (3.49–5.73)	4.62 ± 0.43 (3.44–5.60)	0.314
WTW (mm)	11.66 ± 0.40 (10.70–12.70)	11.75 ± 0.37 (10.90–12.60)	0.214
Tilt (°)	4.93 ± 1.28 (2.00–7.60)	4.93 ± 1.21 (2.20–7.40)	0.981
Decent (mm)	0.13 ± 0.07 (0.03–0.33)	0.13 ± 0.09 (0.03–0.57)	0.756
CCT (μm)	538.04 ± 30.77 (462–611)	540.24 ± 33.66 (470–626)	0.732

Note: Values are presented as mean ± standard deviation (Min – Max).

Abbreviations: UDVA, Uncorrected Distance Visual Acuity; CDVA, Corrected Distance Visual Acuity; IOP, Intraocular Pressure; SE, Spherical Equivalent; D, diopters; ARK, Autorefractive Keratometry; AL, Axial Length; IOLm, IOLMaster 700; ACD, Anterior Chamber Depth; LT, Lens Thickness; WTW, White to White; Decent, Decentration; CCT, Central Corneal Thickness.

Table 2 Postoperative Visual Acuity

	IOL		
	Vivity (n=51)	PureSee (n=51)	P value
UDVA (logMAR)	0.12 ± 0.13 (0.00–0.70)	0.10 ± 0.12 (0.00–0.52)	0.282
CDVA (logMAR)	0.05 ± 0.06 (0.00–0.22)	0.04 ± 0.06 (0.000–0.22)	0.504
UIVA (logMAR)	0.16 ± 0.12 (0.00–0.52)	0.21 ± 0.14 (−0.08–0.52)	0.045
UNVA (logMAR)	0.40 ± 0.21 (0.05–1.00)	0.43 ± 0.22 (0.10–1.00)	0.652

Note: Values are presented as Mean ± Standard deviation (Min – Max).

Abbreviations: IOL, Intraocular lens; UDVA, Uncorrected Distance Visual Acuity; CDVA, Corrected Distance Visual Acuity; UIVA, Uncorrected Intermediate Visual Acuity; UNVA, Uncorrected Near Visual Acuity.

the difference was not statistically significant. Both lenses provided a similar overall range of vision, with the Vivity IOL showing superior results at intermediate distances with a maintained plateau.

Figure 4 presents the contrast sensitivity results under both photopic and mesopic conditions. Under photopic conditions, the PureSee group demonstrated significantly higher contrast sensitivity than the Vivity group at 12 cpd ($P = 0.012$) and 18 cpd ($P = 0.012$). Under mesopic conditions, this trend persisted, with statistically significant differences observed again at higher spatial frequencies, specifically at 18 cpd ($P = 0.038$).

Postoperative questionnaire responses regarding patient satisfaction, recommendation, dependence on near glasses, as well as glare and halo, were analyzed for differences between the PureSee and Vivity groups (Figure 5). A high proportion of patients in both groups indicated they would recommend their IOL, with 72.5% in the PureSee group and 87.5% in the Vivity group responding “Yes.” Similarly, satisfaction rates (“Satisfied” or “Very Satisfied”) were 51.2% for PureSee and 44.8% for Vivity. Regarding the dependence on near glasses, 74.4% of PureSee and 65.8% of Vivity patients reported needing reading glasses (often or always). However, none of these differences reached statistical significance ($P = 0.162$ for Satisfaction, $P = 0.502$ for Recommendation, and $P = 0.621$ for Dependence on near glasses).

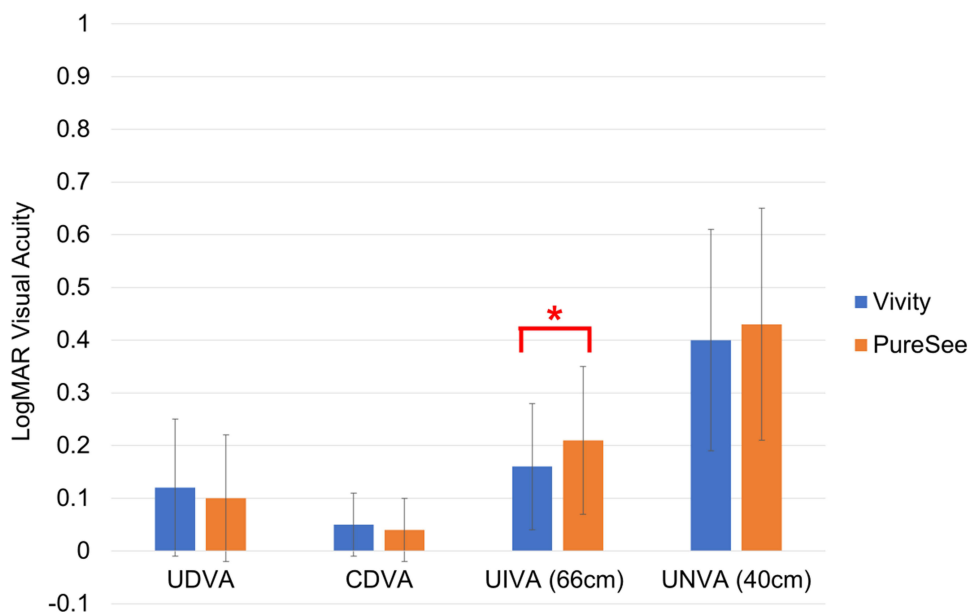


Figure 1 Comparison of mean postoperative visual acuity between the Vivity and the PureSee groups at different distances. Visual acuity is presented in logMAR units. UIVA: Uncorrected intermediate Visual Acuity measured at 66cm distance; UNVA: Uncorrected Near Visual Acuity measured at 40cm distance. Error bars represent standard deviation. Asterisk (*) indicates a statistically significant difference ($P < 0.05$).

Abbreviations: UDVA, Uncorrected Distance Visual Acuity; CDVA, Corrected Distance Visual Acuity.

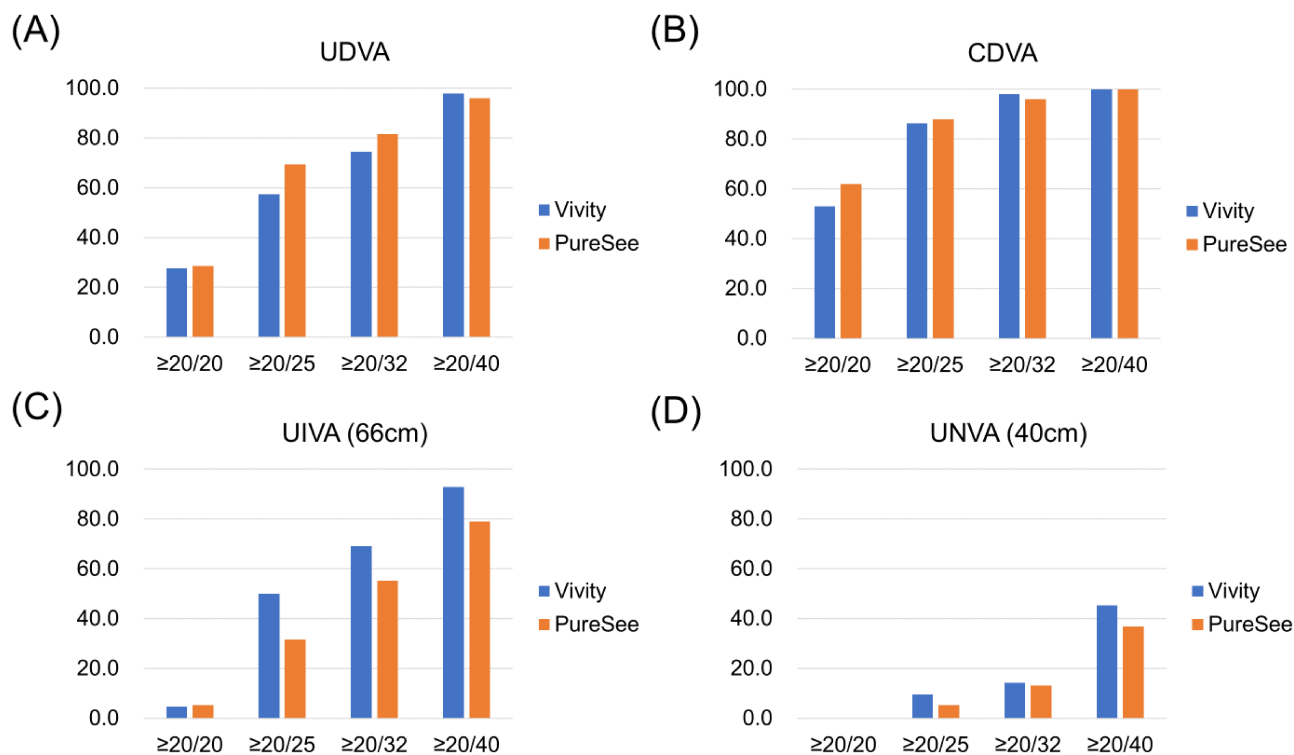


Figure 2 Cumulative Distribution of postoperative visual acuity levels in the Vivity and PureSee groups across different functional distances. (A) Uncorrected distance visual acuity (UDVA), (B) Corrected distance visual acuity (CDVA), (C) Uncorrected intermediate acuity at 66cm (UIVA), (D) Uncorrected near acuity at 40cm (UNVA).

Likewise, although there were almost twice as many patients who reported being “very dissatisfied” in the PureSee group (10.3%) compared to the Vivity group (5.3%), this difference was also not statistically significant ($P = 0.675$). Glare was reported as occurring “always” or “often” by 18.0% of patients in the PureSee group and 2.6% in the Vivity group. Additionally, 12.8% of PureSee patients reported experiencing halo frequently, whereas such responses were not

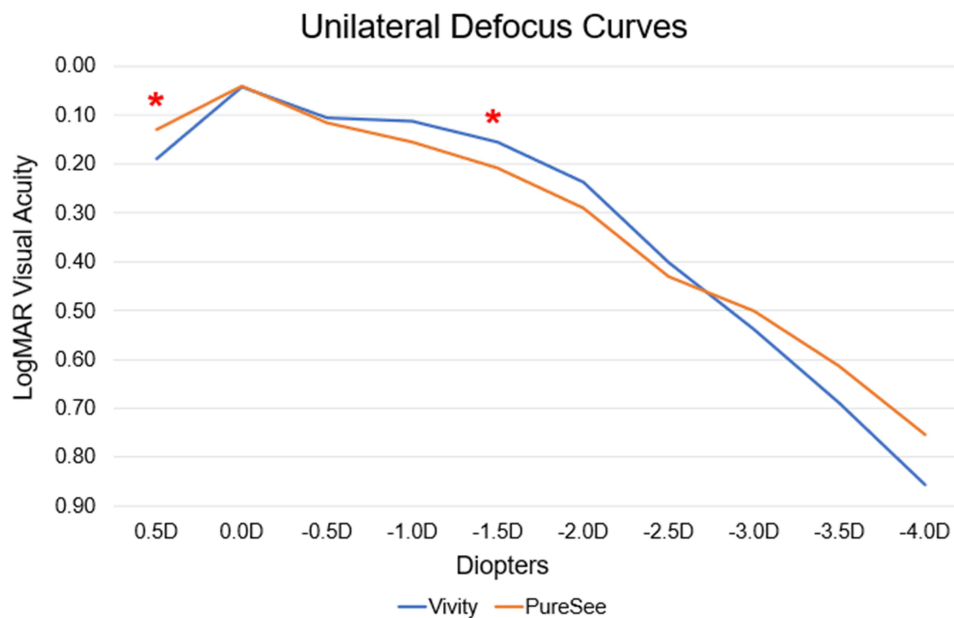


Figure 3 Unilateral defocus curves showing mean visual acuity (logMAR) across defocus levels from +0.5D to -4.0D in the Vivity (blue) and PureSee (Orange) groups. Asterisks (*) indicate statistically significant differences between the groups at corresponding defocus levels ($P < 0.05$).

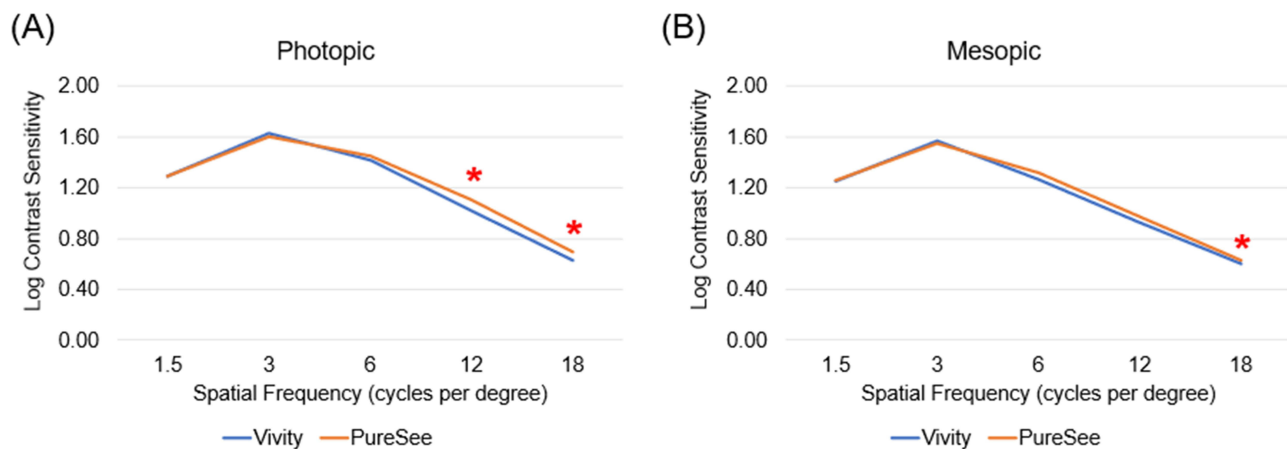


Figure 4 Log contrast sensitivity measured under (A) photopic and (B) mesopic lighting conditions for the Vivity (blue) and PureSee (Orange) groups. Asterisks (*) indicate statistically significant differences between the groups ($P < 0.05$).

observed in the Vivity group. Although the Vivity IOL demonstrated a trend toward fewer photic phenomena, these differences were not statistically significant (-0.15 , 95% CI -0.27 to -0.02 , $P = 0.062$ for Glare, and -0.125 , 95% CI -0.228 to -0.022 , $P = 0.065$ for Halo).

Discussion

This study compared the clinical performance of two non-diffractive IOLs - Vivity and PureSee - focusing on visual acuity across defocus range, contrast sensitivity, and subjective visual experience. Both lenses provided an extended range of vision, as shown by the defocus curves, but exhibited different strengths across distances. Both IOLs demonstrated comparable visual acuity at 6 meters (UDVA and CDVA) and similar near vision. The Vivity group showed statistically superior performance at $-1.5D$, indicating improved performance in tasks requiring intermediate focus.

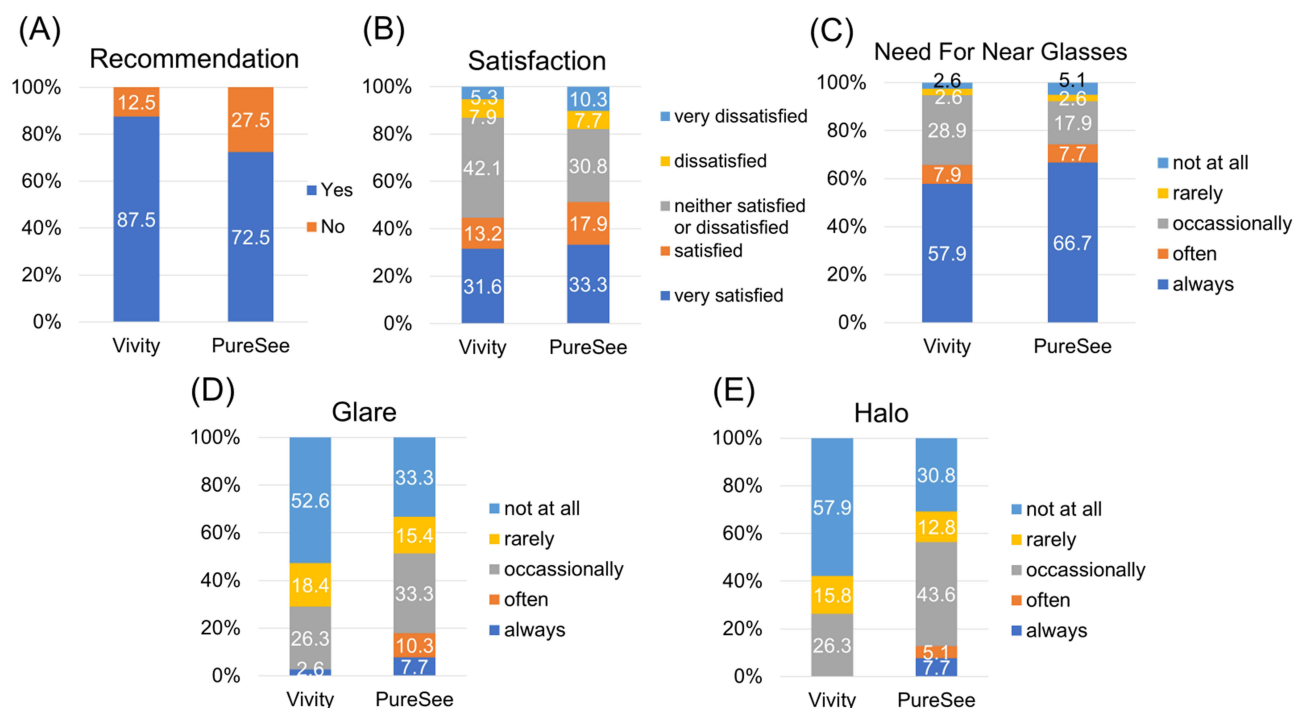


Figure 5 Stick bar graphs illustrating patient-reported outcomes for the Vivity and PureSee groups: **(A)** Willingness to recommend the IOL to others, **(B)** Overall satisfaction, **(C)** Need for near-vision spectacles, **(D)** Frequency of glare, and **(E)** Frequency of halo. Responses were collected using 5-point scale and expressed as percentages.

This aligns with recent findings reporting that PureSee IOL offers a continuous defocus curve from +1.00 D to −2.50 D, maintaining visual acuity of 0.2 logMAR or better across this range.^{9,14} AcrySof Vivity has previously shown significantly better visual acuity than monofocal Clareon lenses, with best-corrected visual acuity improving from 0.4 logMAR to 0.0 logMAR.^{19,20} AcrySof Vivity has also demonstrated significantly higher spectacle independence and patient satisfaction.^{1,19} These reported outcomes are consistent with the optical principles behind each lens: Vivity employs wavefront shaping to stretch the focal point, while PureSee uses controlled spherical aberration to modulate depth of focus. Despite differences in mechanism, both IOLs achieved a comparable defocus profile, suggesting that either lens can be effective for patients seeking improvement in visual function without the drawbacks of diffractive optics. Nonetheless, the better intermediate visual acuity observed in the Vivity group compared to the PureSee group may contribute to a smoother visual experience during everyday tasks involving dynamic changes in viewing distance.

Due to the limited availability of published studies on Clareon Vivity, this study refers to data from AcrySof Vivity as a reference. While the two IOLs differ in material composition, they share the same optical mechanism, both employing wavefront-shaping X-WAVE technology to extend depth of focus.^{11,13,21} As such, AcrySof Vivity serves as the most comparable benchmark currently available in literature to assess the expected visual outcomes of Clareon Vivity. Clareon Vivity incorporates a newer hydrophobic acrylic material, designed to reduce photoptic phenomenon such as glares, to improve visual outcomes.²²

In contrast sensitivity testing, PureSee demonstrated significantly better performance at higher spatial frequencies under mesopic and photopic conditions. This may be attributed to its relatively lower induction of light scatter and more conventional aspheric optics compared to Vivity's wavefront-modifying anterior surface, which may slightly reduce contrast in favor of a smoother defocus profile. These objective differences have also been observed in previous studies, showing that PureSee provides contrast sensitivity similar to monofocal IOLs, while Clareon Vivity may show slight reductions.^{8,10} However, the differences did not lead to significant differences in overall satisfaction in the patient-reported outcomes. While the PureSee group demonstrated better contrast sensitivity, the Vivity group may offer a more comfortable and natural visual experience, especially for patients sensitive to glare and halo. The smoother intermediate

acuity profile and minimal photic disturbances observed with the Vivity IOL align well with daily visual needs such as night driving and frequent focus shifts.

Regarding subjective visual experience, both groups reported high satisfaction and willingness to recommend their IOL, with no statistical difference. Notably, Vivity showed a trend toward fewer reports of glare and halo, which aligns with its design to minimize photic phenomena by avoiding diffractive structures. In contrast, PureSee showed slightly more frequent reports of dysphotopsia, though still within a clinically acceptable range. This is supported by recent studies showing that although better than diffractive lenses and comparable to that of monofocal IOLs, PureSee lenses still led to mild dysphotopsia in some individuals.^{9,10} Similarly, studies on AcrySof Vivity have demonstrated lower incidence of dysphotopsia compared to other multifocal IOLs, with patient satisfaction comparable to or higher than the other lenses evaluated, such as Acrysof PanOptix and PanOptix Torix trifocal IOLs.^{1,23} Ultimately, this distinction may guide IOL selection in patients who are particularly sensitive to night vision disturbances.

Overall, there were limited differences between the properties of both lenses. The Vivity IOL showed better outcomes in terms of postoperative intermediate distance acuity and exhibited a trend toward a lower frequency of photic phenomena compared to PureSee IOL. However, these differences did not reach statistical significance and should therefore be interpreted cautiously. Conversely, the PureSee IOL demonstrated better outcomes in contrast sensitivity under both photopic and mesopic conditions. Taken together, both IOLs provided a broad range of functional vision and high patient satisfaction, with distinct optical advantages that may guide lens selection based on individual visual needs.

There were several limitations including the retrospective nature of the study, relatively small sample size and short follow up period. Baseline pupil size measurements were not collected, although previous literatures suggest that the performance of EDoF IOLs is influenced by pupil size, particularly spherical aberration-based lenses like the PureSee IOL.^{13,14} Variations in pupil size can influence the balance between central and peripheral optical zones, potentially affecting contrast sensitivity and visual quality.^{13,14} As baseline mesopic and photopic pupil measurements were not available in this study, their potential effect on the observed differences in contrast sensitivity between groups cannot be excluded. While the results reached statistical significance, the observed effect size was relatively modest. However, this effect may become more meaningful over time or with a greater proportion of patients receiving PureSee or Vivity IOLs, warranting further investigation. Postoperative higher order aberrations result could support our findings, suggesting the measurement of visual quality using the aberrometer in future study. Further study is needed to better characterise the optical outcomes of Puresee and Clareon Vivity IOLs given the limited availability of peer reviewed comparisons between the two IOLs. Future studies are also recommended to consider patients' lifestyle profiles, which would offer clinical context for selecting the most suitable IOL for specific activities, such as frequent night driving or for individuals with a pre-existing aversion to photic phenomena.

In conclusion, both the PureSee and Vivity IOLs provide satisfactory visual outcomes and patient satisfaction, with distinct optical trade-offs. The Vivity IOL can offer a smoother intermediate visual experience with fewer photic symptoms, which may be especially advantageous for patients concerned about visual quality during daily activities or low-light conditions. Given the diversity in design and optical performance among EDoF IOLs, lens selection should be guided by each patient's visual demands and lifestyle. Personalizing IOL choice based on these priorities therefore remains essential for maximizing postoperative satisfaction and functional vision.

Data Sharing Statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval

All procedures followed the Declaration of Helsinki, and the study was approved by the Institutional Review Board (IRB) of Asan Medical Center, Seoul, South Korea (IRB No. 2025-0925). As this study was a retrospective analysis of medical records, the requirement for written informed consent was waived by the IRB.

Acknowledgments

We would like to thank Editage (www.editage.co.kr) for English language editing.

Funding

This work was supported by a grant of the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant number: RS-2023-00302193); by a grant of the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant number: RS-2024-00438366).

Disclosure

Dr Ronald Yeoh is part of the speaker panel for Alcon and Johnson and Johnson, outside the submitted work. The authors declare no other competing interests in this work.

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