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ORIGINAL RESEARCH

Comparative Visual Performance and Optical Stability of Clareon Vivity and TECNIS PureSee EDoF IOLs in Cataract Patients

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Purpose: Cataracts and presbyopia affect millions worldwide, driving demand for advanced intraocular lenses (IOLs) to restore vision and reduce spectacle dependence. Extended depth of focus (EDoF) IOLs, such as Clareon Vivity and TECNIS PureSee, provide continuous vision with minimal disturbances. Given limited direct clinical comparisons, this research offers a head-to-head analysis of their visual performance and optical stability in cataract patients.

Patients and Methods: This retrospective cohort study analyzed 106 eyes from 72 patients who underwent phacoemulsification with Clareon Vivity or TECNIS PureSee IOL implantation. Primary outcome measures were monocular and binocular uncorrected distance visual acuity (UDVA), uncorrected intermediate VA (UIVA) at 66/80 cm, uncorrected near VA (UNVA) at 40 cm, and longitudinal internal higher-order aberrations (HOAs), specifically total coma. Refractive error (spherical/cylindrical powers [SPH/CYL], spherical equivalent [SE]) and defocus curve (+1.5 D to –3.5 D under mesopic/photopic conditions) were measured at 1 and 3 months postoperatively; HOAs (spherical aberration [SA], coma) and pupil size were assessed at 1 week, 1 month, and 3 months, and contrast sensitivity (CS; 1.5–18 cpd) at 1 month using standardized equipment.

Results: Both IOLs significantly improved UDVA ($p < 0.05$). Clareon Vivity showed superior monocular UIVA at 80 cm at 1 and 3 months ($p = 0.0042$ and $p = 0.0711$, respectively), comparable UIVA at 66 cm and UNVA at 40 cm, a broader defocus range (+0.5 D to –2.0 D), and lower total coma at 1 and 3 months ($p = 0.001$ and $p = 0.0097$) with reduced variability, emphasizing mid-range vision and optical stability advantages. TECNIS PureSee exhibited comparable refractive outcomes and CS, with initial superiority in monocular UNVA at 40 cm at 1 month ($p < 0.05$), providing robust early near vision.

Conclusion: Clareon Vivity excels in intermediate vision, defocus tolerance, and coma stability, while TECNIS PureSee offers strong initial near focus. These differences suggest Clareon Vivity may be particularly suitable for patients prioritizing mid-range stability, while both IOLs provide excellent overall visual performance.

Keywords: EDoF IOLs, cataract surgery, visual performance, coma tolerance

Introduction

Cataracts and presbyopia are prevalent age-related conditions impairing vision globally and affecting quality of life for millions.[1,2] These conditions underscore the need for advanced surgical solutions. Cataract surgery, a frequent procedure, now extends beyond clarity restoration to address presbyopia with innovative intraocular lenses (IOLs).

Extended depth of focus (EDoF) IOLs are used in presbyopia-correcting surgery, providing continuous vision with fewer disturbances, such as halos, compared to multifocal IOLs.[3,4] Their success relies on optical design and stability. Lens misalignment can cause aberrations, such as coma or spherical aberration (SA), affecting visual quality.[5,6] Thus, refining IOL design is vital for better outcomes.

Recent EDoF IOLs include Clareon® Vivity® (Alcon Laboratories, Inc, Fort Worth, Tx, USA) and TECNIS PureSee™ (Johnson & Johnson Surgical Vision, Inc, Irvine, CA, USA). Clareon Vivity employs non-diffractive

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X-WAVE™ wavefront-shaping technology on the anterior surface to stretch and shift light, creating a continuous EDoF while maintaining high light efficiency.[7,8] TECNIS PureSee utilizes a purely refractive wavefront-shaping design with anterior aspheric correction of corneal SA and posterior continuous power gradient, combined with violet-light filtering for enhanced visual quality.[9] Recent optical bench studies show comparable performance between Vivity and PureSee in far and intermediate focus, with similar tolerance to misalignment.[7,10] However, clinical studies directly comparing these two EDoF IOLs remain limited, often relying on optical bench evaluations rather than real-world patient outcomes. This reliance on laboratory data overlooks critical factors such as postoperative adaptation, capsular dynamics, pupil behavior, and neuroadaptation, which can cause divergence between bench and real-world performance.

To address this gap, the present retrospective study aims to yield insights into the visual performance and optical stability of Clareon Vivity and TECNIS PureSee IOLs in cataract patients. This retrospective analysis will provide a head-to-head clinical comparison, supporting informed IOL selection for enhanced patient outcomes.

Material and Methods

Ethics Approval and Consent to Participate

This study was conducted in strict accordance with the ethical principles outlined in the Declaration of Helsinki. The research protocol received approval from Public Institutional Bioethics Committee designated by the Korea Ministry of Health and Welfare (P01-202503-01-033), an independent nationally accredited central IRB. Patient data confidentiality was strictly maintained by anonymizing all personal identifiers prior to data extraction and analysis. Informed consent was waived by the IRB due to the retrospective design.

Study Design

This retrospective cohort study evaluated preoperative and postoperative outcomes in 72 patients (106 eyes) who underwent cataract surgery with EDoF IOL implantation at Fatima Eye Clinic (Changwon, South Korea) between March 2024 and December 2024. Patients selected either the Clareon Vivity IOL (36 patients, 53 eyes) or the TECNIS PureSee IOL (36 patients, 53 eyes) based on personal preference, with implantation performed via phacoemulsification either unilaterally or bilaterally. Outcome data were systematically collected at 1 week, 1 month, and 3 months post-surgery to assess short-term recovery trends and visual stability.

Inclusion and Exclusion Criteria

Eligible patients presented with clinically significant cataracts that required surgical intervention, ensuring a consistent baseline of cataract severity across the study cohort. Participants opted for EDoF IOLs to achieve enhanced spectacle independence for distance and intermediate vision and demonstrated willingness and ability to attend scheduled post-operative visits at 1 week, 1 month, and 3 months, critical for longitudinal data integrity. Eyes with corneal abnormalities (eg, keratoconus, scarring), pupillary irregularities, vitreous opacities, or retinal pathologies (eg, macular degeneration, diabetic retinopathy) that could confound visual outcomes were excluded, as were eyes with glaucoma or high myopia (> –6.0 diopter [D]), those with a history of prior refractive surgery or other ocular procedures potentially altering IOL performance or postoperative recovery. Patients with uncontrolled systemic diseases (eg, diabetes, autoimmune disorders) that might impair healing or visual recovery were also excluded to minimize confounding factors and focus on cataract-specific effects.

Surgical Technique

All surgeries were performed by a single, highly experienced surgeon under topical anesthesia using the Centurion Vision System (Alcon Laboratories, Inc, Fort Worth, TX, USA),[10] ensuring consistent and standardized techniques. To enhance the precision of preoperative and postoperative measurements, advanced equipment such as the Pentacam HR (OCULUS Optikgeräte GmbH, Wetzlar, Hesse, Germany) for corneal tomography and the iTrace Aberrometer (Tracey Technologies, Houston, TX, USA) for wavefront analysis were utilized. These tools provided detailed corneal and refractive data, minimizing procedural variability and ensuring reproducibility of outcomes. A 2.2 mm temporal corneal incision was created, followed by a 5.0–5.5 mm anterior capsulorhexis using standard forceps. Phacoemulsification was performed with controlled power and irrigation pressure to emulsify and aspirate the cataractous lens. The IOL was implanted into the capsular bag, and the incision was self-sealing or sutured if necessary. Postoperative care included topical antibiotics, steroids, and non-steroidal anti-inflammatory drugs to promote healing and reduce inflammation.

Postoperative Examinations

Evaluations were designed to thoroughly assess visual performance under diverse conditions. Refractive errors (spherical/cylindrical powers [SPH/CYL], spherical equivalent [SE]) and pupil size were assessed with the KR-800 Auto Kerato-Refractor (Topcon Corporation, Itabashi-ku, Tokyo, Japan) at 1 week, 1 month, and 3 months. Visual acuity (VA), including monocular and binocular uncorrected intermediate VA (UIVA) at 66 cm and 80 cm, uncorrected near VA (UNVA) at 40 cm, and monocular uncorrected distance (UDVA) and corrected distance VA (CDVA), was measured using ETDRS charts under photopic conditions (85 cd/m^2) at 1 and 3 months, expressed as logarithm of the minimum angle of resolution (logMAR). Defocus curves, monocular and binocular corrected distance defocus curves (providing distance-corrected intermediate and near VA equivalents), were assessed at 1 and 3 months under photopic conditions and at 1 month under mesopic conditions, spanning +1.5 D to –3.5 D, to evaluate the IOLs' depth of focus across a range of visual demands. Higher-order aberrations (HOAs), such as SA, horizontal/vertical coma [coma H/V], total coma (defined as the average of coma H and coma V), were quantified in root mean square (RMS, µm), with variability analyzed over time. Given that pupil size is a known influencer of HOA variability,[11] HOA variation was analyzed in relation to pupil size differences; for visualization of longitudinal patterns in total coma, absolute differences in mean RMS values were calculated between time points (eg, 1 month minus 1 week, 3 months minus 1 week). Contrast sensitivity (CS) was measured monocularly and binocularly at 1.5–18 cycles per degree (cpd) using the Optec® 6500 (Stereo Optical Co, Chicago, IL, USA) at 1 month only.

Statistical Analysis

Data were analyzed using R software (version 4.4.1; R Foundation for Statistical Computing, Vienna, Austria).[12] Generalized Estimating Equations (GEE) models with an exchangeable correlation structure were employed to account for the within-subject correlation between fellow eyes. Categorical variables were analyzed using GEE with appropriate link functions. A p-value < 0.05 indicated statistical significance. No formal a priori sample size calculation was performed as this was a retrospective study.

Results

Optical Characteristics

Supplementary Table 1 summarizes the optical properties of Clareon Vivity and TECNIS PureSee IOLs.[7,9] Both IOLs share similar dimensions but differ in edge design, material, refractive index, and wavefront-shaping technology. Vivity employs X-WAVE™ wavefront shaping and a square-edged posterior surface to minimize posterior capsular opacification. PureSee corrects corneal SA anteriorly and uses posterior wavefront shaping with a frosted 360° square edge for smooth power transitions. These design differences underpin their distinct approaches to extended depth of focus.

Patient Characteristics

The study included 106 eyes from 72 patients (36 patients/53 eyes per group) with balanced gender distribution. Mean age was 61.6 ± 12.1 years (Vivity) and 61.9 ± 8.5 years (PureSee). Preoperative monocular VAs showed no significant intergroup differences (UDVA: 0.59 ± 0.41 vs 0.52 ± 0.39 logMAR; CDVA: 0.26 ± 0.30 vs 0.23 ± 0.31 logMAR; all $p > 0.05$) (Table 1).

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Table 1 Baseline Demographics and Visual Acuity for Both IOL Groups

Parameter	Clareon Vivity	TECNIS PureSee
Age (year)	61.6 ± 12.1	61.9 ± 8.5
Gender mix (Male:Female)	20M:16F	20M:16F
Number of patients	36	36
Number of eyes	53	53
SPH (D)	–0.81 ± 3.27	–0.13 ± 1.92
SE (D)	–1.14 ± 3.34	–0.45 ± 2.03
CYL (D)	–0.66 ± 0.53	–0.64 ± 0.62
Preop UDVA (LogMAR)	0.59 ± 0.41	0.52 ± 0.39
Preop CDVA (LogMAR)	0.26 ± 0.30	0.23 ± 0.31

Notes: Data shown as mean ± standard deviation.
Abbreviations: SPH, spherical power; SE, spherical equivalent; CYL, cylindrical power; D, diopters; LogMAR, logarithm of the minimum angle of resolution; UDVA, uncorrected distance visual acuity; CDVA, corrected distance visual acuity.

Refractive Outcomes

Postoperative SPH, CYL, and SE remained stable in both groups over 3 months with no significant inter-group differences (all $p > 0.05$; Table 2). Mean SE values converged to –0.26 ± 0.36 D (Vivity) and –0.21 ± 0.50 D (PureSee) at 3 months, confirming excellent refractive predictability.

Visual Outcomes

By 3 months, both IOLs achieved excellent monocular UDVA (Vivity: –0.01 ± 0.07 logMAR; PureSee: 0.01 ± 0.09 logMAR; both $p < 0.05$ vs preoperative). Clareon Vivity demonstrated significantly better monocular UIVA at 80 cm at both 1 month (0.19 ± 0.05 vs 0.22 ± 0.05 logMAR, $p = 0.0021$) and 3 months (0.19 ± 0.06 vs 0.22 ± 0.08 logMAR, $p = 0.0426$). At 66 cm, UIVA was comparable between groups. PureSee showed a transient advantage in monocular UNVA at 40 cm at 1 month (0.52 ± 0.05 vs 0.55 ± 0.06 logMAR, $p = 0.0179$), but the difference disappeared by 3 months ($p = 0.7662$). Binocularly, no significant differences were observed at any distance (Table 3).

Table 2 Postoperative Refractive Outcomes (SPH, CYL, SE) at 1 Week, 1 Month, and 3 Months for Both IOL Groups

		Vivity	PureSee	P-Value
SPH (D)	Preop	–0.81 ± 3.27	–0.13 ± 1.92	0.3339
	Postop 1 w	–0.25 ± 0.50	–0.12 ± 0.42	0.1546
	Postop 1 m	–0.25 ± 0.47	–0.15 ± 0.42	0.3032
	Postop 3 m	–0.19 ± 0.32	–0.11 ± 0.50	0.4846
SE (D)	Preop	–1.14 ± 3.34	–0.45 ± 2.03	0.3427
	Postop 1 w	–0.37 ± 0.57	–0.21 ± 0.43	0.1245
	Postop 1 m	–0.36 ± 0.54	–0.26 ± 0.44	0.3243
	Postop 3 m	–0.26 ± 0.36	–0.21 ± 0.50	0.6675
CYL (D)	Preop	–0.66 ± 0.53	–0.64 ± 0.62	0.8531
	Postop 1 w	–0.23 ± 0.32	–0.19 ± 0.26	0.4996
	Postop 1 m	–0.23 ± 0.31	–0.23 ± 0.30	0.9978
	Postop 3 m	–0.15 ± 0.24	–0.20 ± 0.26	0.3986

Notes: Continuous variables were expressed as mean ± standard deviation. For group comparisons, Generalized Estimating Equations (GEE) models were employed to account for the within-subject correlation between the two eyes, replacing traditional independent tests to calculate the p-values. Categorical variables were also analyzed using GEE models with appropriate link functions. A p-value < 0.05 indicated statistical significance.
Abbreviations: SPH, spherical power; CYL, cylinder power; SE, spherical equivalent; D, diopters.

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Table 3 Monocular and Binocular UDVA, UIVA (80 cm, 66 cm), UNVA (40 cm) at 1 and 3 Months Post-Surgery for Both IOL Groups

		Monocular VA (logMAR)			Binocular VA (logMAR)		
		Vivity	**PureSee**	**P-Value**	**Vivity**	**PureSee**	**P-Value**
UDVA (far)	Postop 1 m Postop 3 m	0.03 ± 0.13 –0.01 ± 0.07	0.00 ± 0.09 0.01 ± 0.09	0.2412 0.3684			
UIVA (80 cm)	Postop 1 m Postop 3 m	0.19 ± 0.05 0.19 ± 0.06	0.22 ± 0.05 0.22 ± 0.08	0.0042 0.0711	0.09 ± 0.04 0.11 ± 0.05	0.12 ± 0.04 0.14 ± 0.07	0.0865 0.2283
UIVA (66 cm)	Postop 1 m Postop 3 m	0.33 ± 0.07 0.32 ± 0.08	0.33 ± 0.05 0.33 ± 0.08	0.7718 0.3704	0.23 ± 0.06 0.23 ± 0.06	0.22 ± 0.05 0.24 ± 0.08	0.3545 0.8569
UNVA (40 cm)	Postop 1 m Postop 3 m	0.55 ± 0.06 0.53 ± 0.07	0.52 ± 0.05 0.53 ± 0.07	0.0929 0.6998	0.44 ± 0.06 0.43 ± 0.05	0.41 ± 0.05 0.42 ± 0.06	0.1148 0.6346

Notes: Continuous variables were expressed as mean ± standard deviation. For group comparisons, Generalized Estimating Equations (GEE) models were employed to account for the within-subject correlation between the two eyes, replacing traditional independent tests to calculate the p-values. Categorical variables were also analyzed using GEE models with appropriate link functions. A p-value < 0.05 indicated statistical significance.

Abbreviations: LogMAR, logarithm of the minimum angle of resolution; UDVA, UIVA, UNVA, uncorrected distance, intermediate, near visual acuity.

Defocus Outcomes

Defocus curves demonstrated a continuous range of functional vision for both IOLs. Under mesopic conditions at 1 month (Figure 1A and B), Vivity maintained better intermediate vision (eg, –1.5 D: 0.369 vs 0.400 logMAR, p = 0.0241) and PureSee better near vision (eg, –3.0 D: 0.875 vs 0.835 logMAR, p = 0.0448; –3.5 D: 1.055 vs 1.012 logMAR, p = 0.0147), with no significant binocular differences. Under photopic conditions at 1 month (Figure 1C and D), PureSee performed better at near defocus (−2.5 D to −3.5 D; eg, –2.5 D: 0.520 vs 0.524 logMAR, p = 0.8398 but overall trend favoring PureSee), whereas Vivity excelled at intermediate defocus (−1.0 D to −2.0 D; eg, –1.0 D: 0.131 vs 0.155 logMAR, p = 0.0102; –1.5 D: 0.216 vs 0.268 logMAR, p = 0.0011; –2.0 D: 0.350 vs 0.395 logMAR, p = 0.0050). By 3 months, Vivity's near vision improved markedly (p < 0.05 vs 1 month), resulting in comparable performance to PureSee from −2.5 D to −3.5 D (Figure 1E and F). Binocularly at 3 months, Vivity provided superior vision from +0.5 D to −2.0 D (eg, +0.5 D: –0.003 vs 0.030 logMAR, p = 0.0342; 0.0 D: –0.107 vs –0.067 logMAR, p = 0.0282; –0.5 D: –0.007 vs 0.023 logMAR, p = 0.0265; peak logMAR −0.107 vs −0.067; p < 0.05).

Internal HOA Outcomes

Mean HOA RMS (μm) values for SA, horizontal/vertical coma, and total coma showed no significant differences at individual time points except for total coma at 1 month and 3 months, where Vivity exhibited significantly lower values (1 month: 0.19 ± 0.09 vs 0.37 ± 0.32 μm, p = 0.0012; 3 months: 0.23 ± 0.12 vs 0.38 ± 0.33 μm, p = 0.0172) (Table 4). Pupil size decreased postoperatively in both groups (from preoperative ~4.8 mm to ~4.0–4.7 mm), with a transient significant difference at 1 week (Vivity: 4.38 ± 0.75 mm vs PureSee: 4.04 ± 0.72 mm, p = 0.0411), but no differences at later time points (p > 0.05) (Table 4). Longitudinal analysis using 1-week values as baseline showed markedly smaller absolute changes in total coma for Vivity (0.06 ± 0.08 μm at 1 month and 0.08 ± 0.08 μm at 3 months) than for PureSee (0.12 ± 0.23 μm and 0.13 ± 0.19 μm), confirming sustained optical stability in Vivity (Figure 2). Pupil size differences did not confound these findings.

CS Outcomes

At 1 month, photopic monocular and binocular CS curves were virtually identical between groups across 1.5–18 cpd (Supplementary Figure 1). Mean logCS values at mid-spatial frequencies (1.5–6 cpd) ranged from 1.46–1.40 (Vivity) and

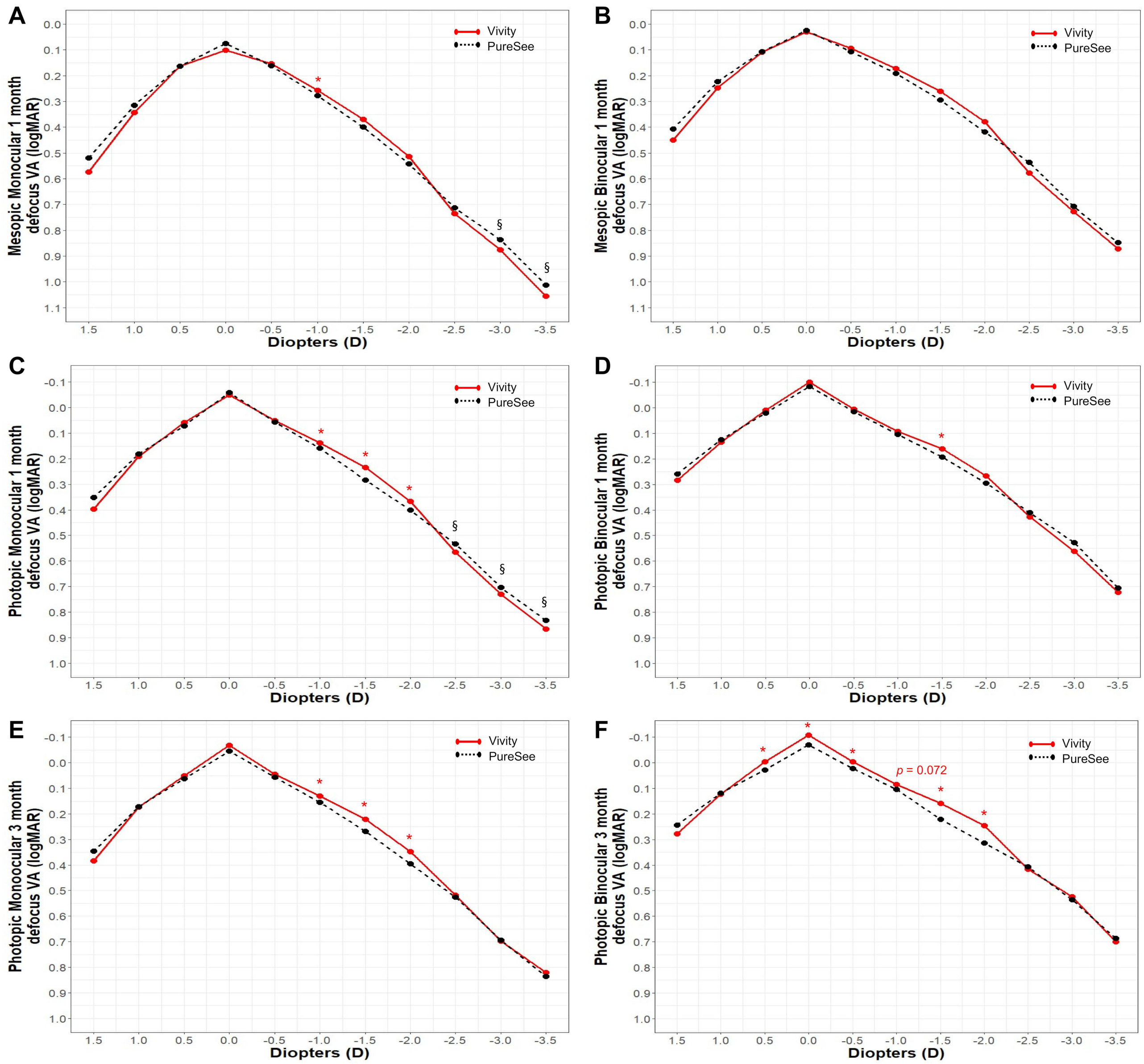

Figure 1 (**A**) Mesopic monocular defocus curve at 1 month; (**B**) Mesopic binocular defocus curve at 1 month; (**C**) Photopic monocular defocus curve at 1 month; (**D**) Photopic binocular defocus curve at 1 month; (**E**) Photopic monocular defocus curve at 3 months; (**F**) Photopic binocular defocus curve at 3 months for Clareon Vivity and TECNIS PureSee IOLs.

Notes: Data shown as means. $^{*,\S}p < 0.05$ between groups.

Abbreviation: LogMAR, logarithm of the minimum angle of resolution.

1.44–1.37 (PureSee) monocularly; from 1.79–1.64 (Vivity) and 1.69–1.71 (PureSee) binocularly, with no significant differences ($p > 0.05$).

Discussion

Clareon Vivity and TECNIS PureSee are EDoF IOLs that demonstrate distinct profiles in visual performance and optical stability, as revealed by our direct comparison in cataract patients.

Studies emphasize refractive predictability as essential for cataract success, noting stable SE, SPH, and CYL within norms.[13,14] Such accuracy curbs complications, evident in broad outcomes for related IOLs.[8,9] As shown in our results, SE/SPH/CYL remained steady (all $p > 0.05$) over follow-ups, matching these benchmarks. Focusing on early patterns, our results affirm both IOLs' reliability, with Vivity's prompt stability aiding minimal issues post-op.

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Table 4 Internal HOAs and Pupil Size Preoperatively and at 1 Weeks, 1 Month, 3 Months Post-Surgery for Both IOL Groups

		Vivity	PureSee	P-Value
SA (RMS, μm)	Preop	0.03 ± 0.13	0.03 ± 0.14	0.8509
	Postop 1 w	–0.06 ± 0.08	–0.05 ± 0.11	0.5468
	Postop 1 m	–0.05 ± 0.07	–0.05 ± 0.19	0.8244
	Postop 3 m	–0.06 ± 0.08	–0.11 ± 0.18	0.1464
Coma H (RMS, μm)	Preop	0.02 ± 0.14	0.03 ± 0.21	0.9469
	Postop 1 w	0.01 ± 0.10	–0.01 ± 0.12	0.3857
	Postop 1 m	0.00 ± 0.09	–0.03 ± 0.15	0.3765
	Postop 3 m	–0.01 ± 0.09	–0.03 ± 0.12	0.3338
Coma V (RMS, μm)	Preop	–0.01 ± 0.15	–0.01 ± 0.20	0.9398
	Postop 1 w	–0.01 ± 0.17	0.00 ± 0.11	0.5938
	Postop 1 m	0.01 ± 0.07	0.01 ± 0.15	0.9211
	Postop 3 m	0.02 ± 0.08	0.02 ± 0.10	0.9124
Total Coma (RMS, μm)	Preop	0.35 ± 0.21	0.36 ± 0.29	0.7334
	Postop 1 w	0.27 ± 0.43	0.29 ± 0.30	0.6815
	Postop 1 m	0.19 ± 0.09	0.37 ± 0.32	0.0010
	Postop 3 m	0.23 ± 0.12	0.38 ± 0.33	0.0097
Pupil size (mm)	Preop	4.88 ± 1.03	4.80 ± 0.81	0.7743
	Postop 1 w	4.38 ± 0.75	4.04 ± 0.72	0.0972
	Postop 1 m	4.33 ± 0.82	4.21 ± 0.94	0.5269
	Postop 3 m	4.66 ± 0.77	4.37 ± 0.66	0.0822

Notes: Continuous variables were expressed as mean ± standard deviation. For group comparisons, Generalized Estimating Equations (GEE) models were employed to account for the within-subject correlation between the two eyes, replacing traditional independent tests to calculate the p-values. Categorical variables were also analyzed using GEE models with appropriate link functions. A p-value < 0.05 indicated statistical significance.

Abbreviations: HOA, higher-order aberration; SA, spherical aberration; Coma H/V, horizontal/vertical coma; Total Coma, the average of coma H and V; RMS, root mean square.

Clinical evidence on EDoF IOLs, including AcrySof IQ Vivity, highlights stable distance VA with UDVA near –0.01 logMAR, emphasizing reliable far vision for daily function.[8,15] Intermediate UIVA plays a key role in minimizing spectacle use for tasks like computing, as noted by Kohnen et al.[16] In our study, both IOLs showed comparable distance

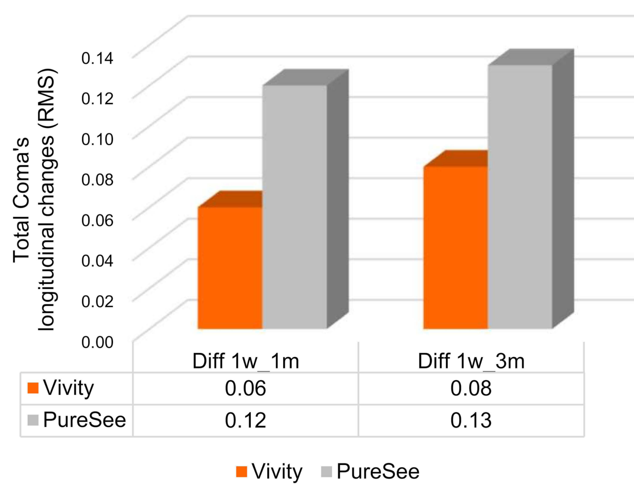

Figure 2 Longitudinal changes in total coma from 1 week to 1 and 3 months between Clareon Vivity and TECNIS PureSee IOLs. RMS, root mean square. Data shown as means.

VA, but Vivity demonstrated superior monocular UIVA at 80 cm ($p = 0.0042$ at 1 month and $p = 0.0711$ at 3 months). Conversely, near VA at 40 cm initially favored PureSee at 1 month due to its stable performance from early post-operatively, while Vivity showed improvement by 3 months through enhanced neuroadaptation, resulting in comparable outcomes.[17] This outcome exceeds ranges in analogous EDoF models,[11] linked to Vivity's non-diffractive optics. Both lenses support daily tasks with reduced glasses dependence: PureSee's prompt near gains aid rapid adjustment needs, whereas Vivity's steady far-to-intermediate performance benefits mid-focused lifestyles. Overall, Vivity's strengths in broader range stability enhance its suitability for diverse visual demands. The absolute differences, although statistically significant, are relatively small (approximately 0.03 logMAR); their clinical significance should be interpreted cautiously in the context of real-world patient needs.

Investigations into defocus curves underscore their value in assessing functional vision breadth for EDoF IOLs, with reports from Savini et al and Alfonso-Bartolozzi et al indicating stable VA up to –2.0 D.[15,18] Our defocus curves demonstrated Vivity's wider range (+0.5 D to –2.0 D, $p < 0.05$), featuring superior intermediate performance under mesopic conditions at 1 month and improved near by 3 months under photopic. This reflects Vivity's greater resilience to defocus, with better absolute VA and extended range of 0.02 logMAR or better, indicating superior resistance to lens decentration and enhanced brain adaptation for quicker recovery across distances. PureSee excelled initially in near defocus (–2.5 to –3.5 D). Extending beyond prior bench evaluations by Niknahad et al,[7] with up to 20% broader functional vision, our data ties this to Vivity's material attributes.[16,19] While PureSee delivers solid near focus, Vivity's enduring mid-range enhances adaptability for screen-intensive routines, improving overall life quality.

Research on HOAs reveals coma sensitivity to IOL decentration, often averaging 0.27 mm in the early (1–3 months) postoperative period and impacting quality.[5,11] Design innovations to curb photic effects are crucial for sustained stability, as seen in Vivity assessments.[7,10] Pupil dynamics further influence tolerance, as explored in studies associating size with distortion reduction.[11,20] In our cohort, mean HOA RMS (SA/coma H/coma V) were equivalent, but Vivity had lower total coma at 1 and 3 months ($p = 0.001$ and $p = 0.0097$, respectively) with reduced longitudinal changes. Despite Vivity's relatively larger pupil size, its lower coma values suggest that pupil dynamics do not confound the superior HOA stability in this study, further emphasizing material-driven advantages in minimizing distortions. This indicates Vivity's twofold reduction in coma variability, enhancing tolerance to misalignment and minimizing visual distortions, surpassing designs like LuxSmart (Bausch & Lomb), which shares a similar fully refractive optic model with PureSee,[11] in misalignment scenarios. This resonates with work by Kohnen et al and Savini et al.[15,16,20] Advancing these insights, our real-world findings affirm material-based consistency,[19] underscoring Vivity's edge over PureSee's variability, particularly since decentration induces coma, while general IOL position movement (distinct from decentration) stabilizes over ~3 months, enabling Vivity's faster neuroadaptation for enhanced early tolerance.[18] Patients thus gain dependable vision in variable settings, minimizing distortions for tasks like driving.

Evaluations of CS stress its importance at mid-frequencies (1.5–6 cpd) for practical tasks like reading or driving, with EDoF IOLs yielding flat curves akin to monofocals.[11,20] Links to coma stability enhance maintenance, as per comparisons by Pedrotti et al.[20] Our photopic results showed similar CS ($p > 0.05$), stable across ranges and consistent with Corbett et al and Alfonso-Bartolozzi et al.[9,19] Vivity's HOA benefits likely support CS in dim conditions, building on monofocal references.[10] Both ensure robust low-light contrast, with Vivity's lower distortions offering extra assurance for evening pursuits.

This study has several limitations that warrant cautious interpretation of the results. The sample size is relatively small (106 eyes from 72 patients), potentially limiting statistical power and generalizability. As a retrospective, single-center design with short-term follow-up (up to 3 months), it risks inherent biases, including selection bias from patient-driven IOL choice based on personal preference. Although GEE models were used to account for inter-eye correlation, the non-randomized design and patient self-selection of IOL type remain important considerations. Additionally, the absence of 3-month CS measurements, IOL tilt/decentration assessments, and patient-reported outcomes (eg, satisfaction questionnaires or spectacle independence rates) may overlook long-term visual quality and subjective experiences. Furthermore, most visual acuity measurements were performed monocularly, which may underestimate real-world binocular performance, particularly for intermediate vision and depth perception in everyday activities. Reliance on uncorrected VA could skew intermediate and near results in patients with residual refractive errors. Despite these constraints, our head-to-head comparison provides valuable initial insights into these novel IOLs. To address these issues, future prospective, randomized, multi-center studies with longer follow-up periods and comprehensive metrics, including patient satisfaction, are planned to validate and expand our findings.

Conclusion

The two IOLs exhibit differences in intermediate vision, defocus tolerance, and HOA stability, attributable to their respective designs and materials, with Clareon Vivity demonstrating particular strengths in sustained mid-range performance and reduced coma variability. These findings offer novel clinical evidence from a direct comparison, guiding IOL selection for cataract patients seeking spectacle independence and enhanced postoperative outcomes.

Abbreviations

CDVA, corrected distance visual acuity; CS, contrast sensitivity; EDoF, extended depth of focus; HOA, higher-order aberration; IOL, intraocular lens; LogMAR, logarithm of the minimum angle of resolution; RMS, root mean square; SA, spherical aberration; SE, spherical equivalent; UDVA, uncorrected distance visual acuity; UIVA, uncorrected intermediate visual acuity; UNVA, uncorrected near visual acuity.

Data Sharing Statement

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

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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