ARTICLE

Visual performance and subjective experience 3 months and 12 months after combined implantation of 2 new complementary continuous phase multifocal intraocular lenses

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Purpose: To assess the 3-month and 12-month postoperative visual performance and subjective quality of vision (QoV) after combined implantation of complementary continuous phase multifocal intraocular lenses (IOLs).

Setting: Private practice, United Kingdom.

Design: Case series.

Methods: The study enrolled 44 patients undergoing phacoemulsification with implantation of an Artis Symbiose Mid in the dominant eye and an Artis Symbiose Plus in the nondominant eye. Refraction, uncorrected distance visual acuity (UDVA), corrected distance visual acuity, uncorrected intermediate visual acuity (UIVA), uncorrected near visual acuity (UNVA), electronic reading desk, and a QoV questionnaire were evaluated at 3 months and 12 months postoperatively.

Results: The mean binocular UDVA was −0.06 ± 0.08 logMAR and −0.07 ± 0.06 logMAR at 3 months and 12 months ($P = .097$), respectively. The mean binocular UIVA was 0.03 ± 0.13 logMAR and 0.03 ± 0.10 logMAR ($P = 1.0$), respectively. The mean binocular UNVA was 0.07 ± 0.10 logMAR and 0.07 ± 0.08 logMAR ($P = .875$), respectively. There was a significant improvement in QoV for both day and night between 3 and 12 months, with a significant reduction in halos at 12 months. Spectacle independence was reported in 93.2% of cases at 12 months.

Conclusions: The Artis Symbiose Mid and Plus IOL combined implantation provided an excellent range of uncorrected vision at 3 and 12 months. There was a significant improvement in QoV and less halos at 12 months. This IOL combination provided very high rates of complete spectacle independence.

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In modern lens–based surgery, there is an increasing demand for postoperative continuous vision from far to near distances and to ultimately provide complete spectacle independence for patients. There are a range of different methodologies and intraocular lenses (IOLs) at present that seek to provide this postoperative outcome, including bifocal, trifocal, extended depth-of-focus (EDOF), and monofocal IOLs using a monovision approach.[1–7] EDOF IOLs have been introduced more recently to provide continuous vision from far to intermediate vision with no out-of-focus image as found with multifocal IOLs. Both multifocal IOLs and EDOF IOLs appear to provide a range of clear vision; however, some drawbacks persist such as unwanted dysphotopsias in some patients.[8] EDOF IOLs appear to produce fewer dysphotopsias; however, uncorrected near vision is inferior to bifocal or trifocal IOLs.[9,10] Therefore, this has led to the methodology of combined implantation of an EDOF and a trifocal IOL. Previous studies outline the outcomes using the combination of an EDOF IOL in the dominant eye and a trifocal IOL in the fellow eye, where the benefits of EDOF IOLs would be present in the dominant eye and the trifocal IOL would simultaneously provide the required uncorrected near vision that is lacking in EDOF IOLs.[11–14] The study highlighted that a range of clear vision with high spectacle independence and subjective satisfaction can be achieved with this mix-and-match approach.

More recently, a new complementary continuous phase multifocal IOL combination approach has been introduced.

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This approach uses 2 complementary IOLs in the same patient, with one IOL designed for superior intermediate vision and the other designed for superior near vision, and incorporates a newly patented continuous through-focus phase to achieve spectacle independence. Laboratory studies have sought to evaluate the optical bench performance; however, there is a scarcity of clinical studies on this complementary IOL combination.[15,16] Therefore, this current paper sought to present the clinical outcomes and the patient-reported outcomes up to 12 months postoperatively for this new IOL combination.

METHODS

This study recruited consecutive patients who underwent refractive lens exchange with implantation of complementary multifocal IOLs between April 2021 and May 2022. The IOL with superior intermediate vision was implanted in the dominant eye and the IOL with superior near vision in the nondominant eye. This study used only unidentifiable patient data, and additionally, all patients gave their informed consent for their anonymized data to be submitted for audit and publication. Exclusion criteria were preoperative corneal astigmatism of 1.2 diopters (D) or greater, pupil diameter of less than 2.8 mm, any other ocular pathology, ocular inflammation, corneal surgery or disease, a history of glaucoma or retinal detachment, neuro-ophthalmic disease, and macular disease.

Full ophthalmologic assessment was performed on all patients preoperatively. Uncorrected (UDVA) and corrected (CDVA) distance visual acuities were evaluated with logarithmic acuity (logMAR) charts, and uncorrected intermediate (UIVA) and near (UNVA) visual acuities were evaluated with Radner reading charts (70 cm and 40 cm). Slitlamp examination, Goldmann tonometry, and dilated fundoscopy were completed. In addition, corneal topography (OPD-Scan II, Nidek Co., Ltd.), corneal tomography (Pentacam, Oculus Optikgeräte GmbH), retinal optical coherence tomography (Cirrus 4000 OCT, Carl Zeiss Meditec AG), stereopsis (TNO stereotest), and pupillometry (Optikon Keratron Scout, Schwind eye-tech-solutions GmbH & Co. KG) were also completed. Biometry was completed with the IOLMaster700 (Carl Zeiss Meditec AG). The Hoffer Q formula was used when the axial length was less than 22 mm, and the Haigis formula was used when the axial length was 22 mm or more, and with axial lengths >26 mm, a partial axial length modification to ensure there was at maximum only 0.5D increase over optimised Haigis output, was incorporated based on axial length optimization lens power calculations.[17] Each patient's ocular dominance was determined using the pointing methodology, which was also required to agree with which eye the patient reports to use for sighting a camera and/or a rifle. The pointing methodology involved the following steps: patients were asked to point at a spot light source 6 m in the distance ensuring that their finger and the light source were visually aligned; each eye was then occluded, and the eye where the separation between the finger and the light source was smallest was considered to be the dominant eye.

Patients were assessed at 3 months and 12 months postoperatively, with the main postoperative examinations including subjective refraction, UDVA, CDVA, UIVA, and UNVA. Defocus curve assessment was obtained monocularly and binocularly using the best distance refractive correction. The visual acuity was then measured using +1.50 to −5.0 D IOLs over the distance-corrected refraction in 0.5 D steps. Letters were randomized between each lens presentation. Reading performance was assessed using the Salzburg Reading Desk postoperatively at fixed distances of 40 cm and 66 cm.[18,19] Reading acuity in logMAR, reading velocity in words per minute (wpm), reading duration in seconds, and letter size are reported in this study. Measurements were taken from the smallest readable sentences read with a minimum velocity of 80 wpm. Stereopsis (TNO stereotest) and contrast sensitivity (Pelli-Robson) were assessed postoperatively. Quality of vision (QoV) was assessed through a previously validated QoV questionnaire.[20] The questionnaire assessed various phenomena and dysphotopsias where the patients report their answers on a Likert scale, and pictures are used to aid understanding. In addition, a linear 0 to 10 scale was used to define each patient's overall subjective QoV. Furthermore, patient experience was assessed through a purpose-developed satisfaction questionnaire regarding their distance, intermediate, and near vision. Patients also reported their dependence on spectacles and overall satisfaction, as outlined and used previously.[12]

Intraocular Lens

The Artis Symbiose Mid IOL (Cristalens) and Artis Symbiose Plus IOL (Cristalens) are complementary continuous phase multifocal IOLs that are used as a combination in the same patient. Both IOLs are designed with the modulated profiles technology to obtain progressive asymmetrical depth of field with complementarity in binocular vision to provide full focus vision from 40 to 90 cm without compromising distance vision (Supplemental Figure 1, *a* and *c*, available at http://links.lww.com/JRS/A917). Furthermore, the IOLs have a diffractive profile with the newly patented profile to give a continuous through-focus phase near to intermediate vision, while maintaining high-contrast distance vision (Supplemental Figure 1, *b*, available at http://links.lww.com/JRS/A917). Supplemental Figure 2 (available at http://links.lww.com/JRS/A918) explains how the through-focus phase transfer function is mathematically obtained from the point spread function and optical transfer function. The phase gives information on vision sharpness, and continuous sharp vision is associated with the constant phase, whereas a phase inversion (a gap) for a standard trifocal will result in a blurred image (typically between intermediate and near vision).

The Artis Symbiose IOL combination provides continuous addition from 1.5 to 3.75 D, where the Artis Symbiose Mid IOL provides superior intermediate vision with a maximum at 1.75 D and the Artis Symbiose Plus IOL providing superior near vision with a maximum at 3.25 D.

The IOL is aspheric with −0.23 μm spherical aberration and has a diffractive profile on the anterior surface.[16] It is made of hydrophobic material with 4 closed-loop haptics. It has a 6.00 mm optic diameter and a 10.79 mm overall length. The available powers are +10.0 to +35.0 D in 0.50 D increments.

Surgical Technique

The same experienced surgeon (J.E.M.) completed each surgery with standard on-axis clear corneal phacoemulsification performed under sub-Tenon anesthesia. The foldable IOL was inserted through a 2.4 mm incision. All patients had the steepest axis marked in an upright position, and all incisions were placed on this steepest meridian. Implantation of the multifocal IOL was into the capsular bag after the creation of a 5.5 mm anterior capsulorhexis as defined by the Zeiss Callisto Eye (Carl Zeiss Meditec AG). The dominant eye was operated on first with implantation of the IOL with superior intermediate vision, and then, the second eye was operated on 1 week later with the IOL that provides superior near vision. With each case, the refractive aim was emmetropia.

Statistical Analysis

Statistical analysis was performed using R (R Core Team 2021) and Excel (Microsoft Corp.). Preoperative and postoperative parameters were reported in means and SDs or percentages. The median and interquartile range were used to outline the Salzburg Reading Desk findings. A comparison between the postoperative

parameters was made using the paired *t* test when assessing continuous normal data and the Wilcoxon rank-sum test for assessing nonparametric data. For all statistical analyses, the level of significance was $P < .05$. A sample size of 36 patients is required to detect a clinically significant difference in QoV of 0.6 between the means at the 2 postoperative stages, assuming a SD in QoV of 0.9 using a 2-tailed *t* test of the difference between means with 80% power and a 5% level of significance. Hence, the current sample size is enough for our study to have a power of at least 80%.

RESULTS

This study included 88 eyes of 44 patients with a mean age of 56 ± 7.75 years (45 to 74 years). Table 1 outlines the demographics and the preoperative clinical data.

Visual Acuity

Table 2 outlines the mean postoperative logMAR values for UDVA, CDVA, UIVA, and UNVA. There was no significant difference in monocular and binocular UDVA, UIVA, and UNVA between the 2 postoperative assessments. Figure 1 displays the binocular cumulative UDVA, UIVA, and UNVA. Comparison of postoperative UDVA and CDVA is shown in Supplemental Figure 3 (available at http://links.lww.com/JRS/A919) where it was found that 72.7% and 70.5% showed the same UDVA and CDVA with both IOL designs at 12 months.

Supplemental Figure 4 (available at http://links.lww.com/JRS/A920) shows the mean defocus curve at 3 months postoperatively, both binocularly and the monocularly for the 2 IOL designs. The binocular defocus curve shows a peak at −2.00 D and −2.5 D defocus and at 0 D defocus, where visual acuity is 0 logMAR or better at these points. There is a slight drop off at 1 D of defocus; however, visual acuity remains better than 0.1 logMAR. Monocular defocus curves show a similar pattern. The Mid IOL peaks at −2.00 D and −2.5 D defocus and at 0 D defocus, compared with the Plus IOL peaking at −2.5 D defocus and at 0 D defocus. The Plus IOL shows a greater drop off at −1 D defocus.

Refractive Outcomes

Table 2 outlines the refractive outcomes where there was no significant difference between the 2 IOLs at each postoperative assessment. The refractive predictability is shown in Figure 2 where it was found that 84.1% of Mid and Plus IOL eyes were within ±0.50 D of the refractive target at 12 months postoperatively. One hundred percent of eyes were within ±1.00 D of the refractive target with both IOLs at both postoperative assessments. Supplemental Figure 5 (available at http://links.lww.com/JRS/A921) outlines the postoperative subjective refractive cylinder of both IOL designs, where 81.9% and 88.6% of eyes had 0.50 D or less at 12 months.

Patient-Reported Outcomes

Table 3 outlines the postoperative QoV questionnaire responses. A statistically significant reduction in the incidence of glare ($P = .035$, Wilcoxon rank-sum test) and halos ($P < .001$, Wilcoxon rank-sum test) between the 2 postoperative assessments was found. Overall daytime and nighttime QoV scores increased at 12 months.

The patient satisfaction questionnaire outcomes are highlighted in Table 4. It was found that 95.5% and 93.2% of patients reported complete spectacle independence at the 2 respective postoperative assessments. Of all patients, 93.2% reported to be more than fulfilled or fulfilled with the procedure at 1 month compared with 100% at 12 months.

Reading Performance

Reading performance found with the Salzburg Reading Desk at fixed distances of 40 cm and 66 cm is outlined in Supplemental Table 1 (available at http://links.lww.com/JRS/A922). A median binocular reading acuity of −0.04 logMAR at 40 cm and 0.02 logMAR at 66 cm was found and a reading speed of 115 wpm and 104 wpm at the 2 respective distances. No statistically significant difference was found between reading acuity, reading speed, reading duration, and letter size when comparing the Mid IOL with Plus IOL for both 40 cm and 66 cm.

Stereoacuity and Contrast Sensitivity

Twelve months postoperatively, all patients showed at least gross stereoacuity, with 90.1% achieving 480 seconds of arc and better and 50% achieving 120 seconds of arc and better. Binocular contrast sensitivity was 1.72 ± 0.15 at 12 months postoperatively.

Table 1. Demographics and clinical data

	Preop	
Parameter	**Artis Symbiose Mid**	**Artis Symbiose Plus**
No. of patients (eyes)	44 (44)	44 (44)
Age (y), mean ± SD (range)	56 ± 7.75 (45, 71)	
Gender, M/F (%)	38.6/61.4	
AL (mm), mean ± SD (range)	23.31 ± 1.26 (20.56, 27.19)	23.29 ± 1.24 (21.03, 27.26)
Power of the implanted IOL (D), mean ± SD (range)	23.87 ± 4.46 (10.5, 35.0)	23.91 ± 4.37 (10.0, 32.5)
Clinical, mean ± SD (range)		
Sphere (D)	1.41 ± 2.64 (−7.00, 6.50)	1.31 ± 2.69 (−7.5, 5.5)
Cylinder (D)	−0.49 ± 0.36 (−1.5, 0)	−0.38 ± 0.38 (−1.75, 0)
MSE (D)	1.16 ± 2.66 (−7.50, 6.13)	1.13 ± 2.68 (−7.88, 5.13)
CDVA	−0.04 ± 0.13 (−0.2, 0.40)	−0.05 ± 0.11 (−0.20, 0.40)

AL = axial length; MSE = manifest spherical equivalent

Table 2. Comparison of 1-month and 12-month postoperative clinical data

	Postop 1 Mean ± SD (range)		Postop 2 Mean ± SD (range)		*P* value (comparison of postop 1 with postop 2)	
	Artis Symbiose Mid	Artis Symbiose Plus	Artis Symbiose Mid	Artis Symbiose Plus	Artis Symbiose Mid	Artis Symbiose Plus
Parameter	**44 (44)**	**44 (44)**	**44 (44)**	**44 (44)**	**44 (44)**	**44 (44)**
Sphere (D)	0.26 ± 0.40 (−0.75, 1.25)	0.21 ± 0.41 (−0.50, 1.50)	0.23 ± 0.33 (−0.50, 0.75)	0.27 ± 0.39 (−0.25, 1.50)	0.602	0.132
Cylinder (D)	−0.38 ± 0.33 (−1.25, 0)	−0.37 ± 0.30 (−1.25, 0)	−0.40 ± 0.31 (−1.25, 0)	−0.33 ± 0.28 (−1.25, 0)	0.523	0.313
MSE (D)	0.07 ± 0.41 (−0.75, 1.13)	0.03 ± 0.37 (−0.63, 1.13)	0.03 ± 0.33 (−0.75, 0.75)	0.11 ± 0.35 (−0.38, 1.13)	0.433	0.027
UDVA (logMAR)	0.02 ± 0.10 (−0.12, 0.30)	0.02 ± 0.09 (−0.14, 0.30)	0.01 ± 0.07 (−0.10, 0.14)	0 ± 0.09 (−0.14, 0.22)	0.297	0.187
Binocular UDVA (logMAR)	−0.06 ± 0.08 (−0.20, 0.12)		−0.07 ± 0.06 (−0.20, 0.10)		0.097	
UIVA (logMAR)	0.07 ± 0.12 (−0.20, 0.30)	0.11 ± 0.14 (−0.20, 0.40)	0.06 ± 0.09 (−0.10, 0.30)	0.11 ± 0.14 (−0.10, 0.60)	0.352	0.925
Binocular UIVA (logMAR)	0.03 ± 0.13 (−0.20, 0.30)		0.03 ± 0.10 (−0.10, 0.30)		1	
UNVA (logMAR)	0.17 ± 0.13 (0, 0.60)	0.11 ± 0.11 (−0.1, 0.50)	0.18 ± 0.12 (−0.10, 0.50)	0.11 ± 0.10 (−0.10, 0.40)	0.660	0.989
Binocular UNVA (logMAR)	0.07 ± 0.10 (−0.1, 0.40)		0.07 ± 0.08 (−0.10, 0.30)		0.875	
CDVA	−0.05 ± 0.06 (−0.12, 0.14)	−0.06 ± 0.06 (−0.20, 0.10)	−0.05 ± 0.05 (−0.14, 0.14)	−0.06 ± 0.05 (−0.14, 0.06)	0.810	0.745

MSE = manifest spherical equivalent

Complications

No eyes required Nd:YAG capsulotomy. Furthermore, 3 eyes required further laser enhancement with laser in situ keratomileusis (LASIK), and 1 eye received transepithelial photorefractive keratectomy (transPRK) for residual refractive error. No other adverse events occurred.

DISCUSSION

There are various methodologies that strive to achieve freedom from spectacles in modern lens–based surgery. This current study sought to outline the postoperative outcomes of a new multifocal IOL design. The IOLs are a complementary IOL combination using a newly patented diffractive profile to provide a continuous through-focus phase from intermediate to near vision. The combination works by implanting one IOL that provides superior intermediate vision, by dedicating a larger amount of light energy to a lower addition, with the other IOL providing superior near vision by dedicating a larger amount of light energy to a high addition, with the aim to provide continuous clear distance to near uncorrected vision.

There are limited studies on this combination; however, a laboratory study found a superior monocular UIVA compared with conventional trifocal IOLs.[15] In addition, the theoretical total depth of focus for the Mid and Plus combination was reported as 2.90 D.[16] It appears that this new combination offers the ability to provide a range of clear vision, but there is a scarcity of clinical studies to support this. However, a clinical study of 20 patients at 1 to 2 months postoperatively outlined a range of clear vision through defocus curve assessment and found a high subjective satisfaction.[21] Further clinical studies are required, especially over a longer postoperative period. Therefore, the purpose of this study was to outline the objective visual and refractive outcomes and the subjective patient-reported outcomes, up to 1 year after the implantation of this new IOL combination.

In this current study, both IOLs showed good UDVA, with no significant difference found between the 2 IOL designs at both postoperative assessments (Table 2). The postoperative mean binocular UDVA was excellent (−0.06 ± 0.08 logMAR) and did not alter at 1 year, which may be due to the high refractive predictability, and that all patients in this study were refractive lens exchange patients with good preoperative CDVA. The binocular mean UIVA and UNVA were excellent and stable between the 2 postoperative assessments (Table 2). Other similar studies reporting on a mix-and-match approach show a range of UIVA from 0.03 to 0.13 logMAR and a range of UNVA of 0.02 to 0.18 logMAR.[12–14,22,23] A study that compared 3 diffractive trifocal IOLs found a binocular UIVA of 0.04 ± 0.07 logMAR, 0.00 ± 0.10 logMAR, and 0.06 ± 0.06 logMAR and a binocular UNVA of 0.02 ± 0.11 logMAR, 0.01 ± 0.12 logMAR, and 0.03 ± 0.09 logMAR, respectively.[24] This shows that this combination is comparable with bilateral trifocal IOL implantation, with trifocal IOLs showing minimally superior UNVA; however, a direct comparison of this IOL combination with bilateral trifocal IOLs is required. In this

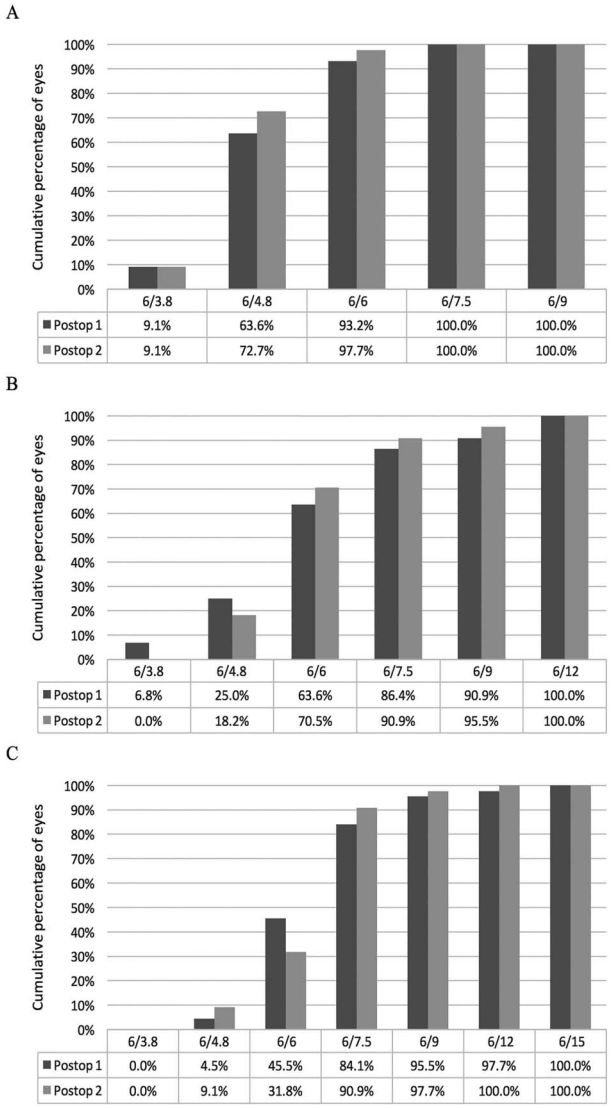

Figure 1. Cumulative binocular (*a*) UDVA, (*b*) UIVA, and (*c*) UNVA at 3 months and 12 months postoperatively.

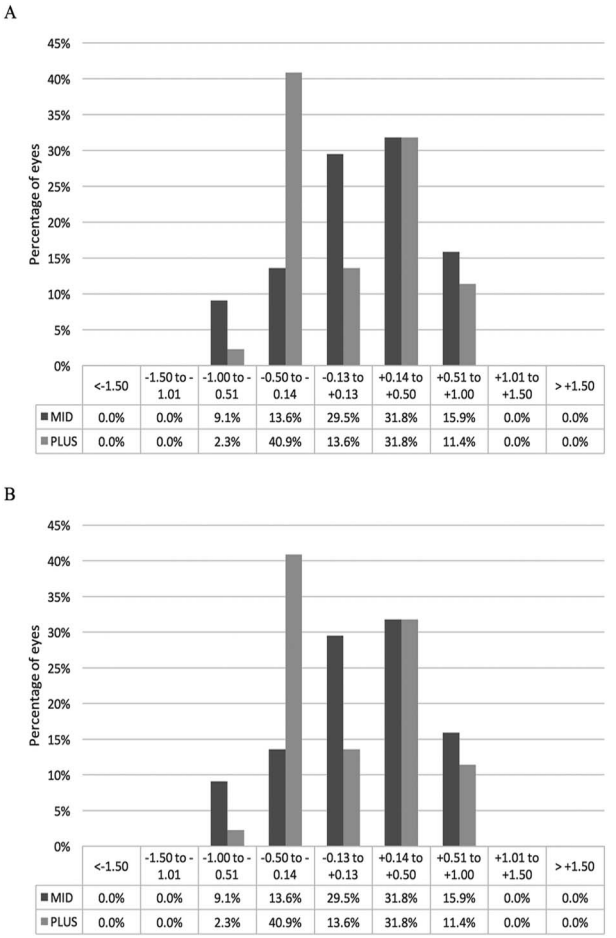

Figure 2. Accuracy to the intended spherical equivalent refraction for both IOL designs at (*a*) 3 months and (*b*) 12 months postoperatively.

complementary IOL combination, the Mid IOL is designed to give superior intermediate vision. Comparison of this new IOL with EDOF IOLs, which are also designed to optimize intermediate vision, appears to show similar UIVA outcomes.[10,14] However, an initial study looking at the early outcomes of an EDOF IOL presented a monocular UNVA of 0.32 ± 0.15 at 1 month, which is significantly reduced when compared with the Mid IOL in this study.[25] It appears that the Mid IOL provides very good intermediate vision and also achieves a high level of UNVA.

The Plus IOL is specifically designed for enhanced near vision, and this study found a monocular UNVA of 0.11 ± 0.11 logMAR and 0.11 ± 0.10 logMAR at the 2 respective assessments. Furthermore, the intermediate vision with the Plus IOL also appears to be excellent despite this IOL designed for superior near vision and is comparable with other trifocal IOLs.[26,27]

Assessment with the reading desk also outlined excellent visual outcomes, and it appears that the reading desk parameters are superior in comparison with other studies. A study of diffractive trifocal IOLs showed a binocular intermediate median reading acuity of 0.10 logMAR and a reading speed of 98 wpm and a binocular near median reading acuity of 0.11 logMAR and a reading speed of 101 wpm, which is inferior to that found in this current study.[19] Superior reading acuity results with this study were also found when compared with other similar studies of trifocal IOLs.[18,28] Direct comparison with other trifocal IOLs and mix-and-match approaches would again be beneficial. The parameters assessed with the reading desk did not show any significant difference between the 2 IOL designs for either the near or intermediate vision, further outlining the effectiveness of the 2 IOL designs at providing both near and intermediate vision.

Defocus curve assessment further highlights the excellent uncorrected vision achieved with this IOL combination and similar to that reported previously.[21] With the binocular defocus curve, the peak visual acuity is observed in the distance with a gradual reduction to a viewing distance of 1 m, which then improves again to better than 0 logMAR between 66 and 50 cm. There is then a slow decrease in visual acuity to 33 cm; however, visual acuity remains 0.2 logMAR

Table 3. Comparison of 1-month and 12-month postoperative visual phenomena data

Parameter	Postop 1	Postop 2	*P* value
Glare	0.61 ± 0.72 (0, 3)	0.36 ± 0.53 (0, 2)	.035
Halos	0.91 ± 0.77 (0, 3)	0.39 ± 0.62 (0, 2)	<.001
Starburst	0.27 ± 0.62 (0, 3)	0.16 ± 0.48 (0, 2)	.279
Hazy vision	0.11 ± 0.54 (0, 3)	0.02 ± 0.15 (0, 1)	.423
Blurred vision	0.16 ± 0.48 (0, 2)	0.05 ± 0.21 (0, 1)	.089
Distortion	0	0	1.000
Double vision	0	0	1.000
Vision fluctuate	0.02 ± 0.15 (0, 1)	0.02 ± 0.15 (0, 1)	
Depth perception	0	0	1.000
QoV day	8.89 ± 0.92 (6, 10)	9.27 ± 0.66 (8, 10)	.004
QoV night	7.77 ± 1.34 (4, 10)	8.57 ± 1.19 (5, 10)	<.001

QoV = quality of vision
Visual phenomena calculated on a scale 0 (not at all) to 3 (very). QoV is calculated on a scale 0 (worst) to 10 (best). Values represent mean ± SD (range).

or better until this point. The continuous and complementary intermediate and near additions of this new IOL combination appear to provide an excellent range of vision with smooth transitions between different viewing distances, with 2 peaks in the distance and 66 cm. This is in contrast to defocus curves found with an EDOF and trifocal IOL combination, which shows peak visual acuity in the distance and then decreases gradually until 50 cm.[11] There is then stable visual acuity to 33 cm. In addition, the visual acuity between 66 and 40 cm is superior with this new complementary IOL combination when compared with the EDOF and trifocal IOL combination.[11] The monocular defocus curves further support that intermediate and near visual acuity is excellent with both IOL designs assessed independently, where vision is better than 0.2 logMAR from distance viewing to approximately 40 cm.

Both IOLs showed high predictability, similar to a trifocal IOL (76%) and similar to our previous study of rotationally asymmetric multifocal IOLs (Figure 2).[29,30] There was no significant difference between the refractive parameters postoperatively between the 2 IOL designs (Table 2). The refractive outcomes are stable with no statistically significant difference between the 2 postoperative assessments. In addition, with this being a new IOL design, one would expect further improvement in refractive outcomes with subsequent adjustments to A-constants.[31]

Two Mid IOL eyes required further laser enhancement. TransPRK was performed 8 months after implantation with 1 patient to correct a residual refractive error of −0.5/−1.00 × 110. Another Mid IOL eye received LASIK, correcting +1.25/−0.25 × 155 of residual refractive error. Two Plus IOL eyes required LASIK with residual refractive errors of +1.25/−0.25 × 160 and 0/−1.50 × 85. Each patient noticed an improvement in uncorrected vision and was happy with their overall QoV at 12 months.

Patient-reported outcomes were also outlined in this study. The individual questions of a QoV questionnaire are outlined in Table 3. It appears that patients do report experiencing some glare and halos at this early postoperative stage; however, at the early assessment, no patient reported to be very intolerant of halos. Both symptoms significantly reduced at the second postoperative assessment. Overall QoV scores appear to be high, with scores significantly improving again at 1 year. QoV outcomes were similar to rotationally asymmetric multifocal IOLs found in our previous study that used the same QoV scale.[32,33] Another previous study, outlining combined EDOF and trifocal IOL outcomes and also used the same scale for reporting subjective outcomes, shows that the Mid and Plus IOL combination shows a higher incidence of halos at the 1-month postoperative assessment and a lower overall QoV nighttime score.[11] However, at the 12-month assessment, halos and the overall nighttime score were superior with the Mid and Plus combination.

Assessment of patient satisfaction and visual function shows a high level of postoperative satisfaction (Table 4). At the early postoperative assessment, 93.2% of patients reported that their expectations were "more than fulfilled" or "fulfilled" by the postoperative outcome, and this increased to 100% at 12 months. No patient reporting that their expectations were "not fulfilled at all." High subjective visual function was achieved, with no patient reporting a severe problem in their distance vision and 100% of patients reported that their intermediate and near vision was either "clear" or "a slight problem" at both postoperative assessments. At 12 months, 93.2% of patients reported to never need reading spectacles, with only 3 patients reporting to need reading spectacles "occasionally." A recent literature review that looked at 19 studies of a trifocal IOL found a spectacle independence rate of 89.6%, which is inferior to that found with the combination in this current study.[34] Furthermore, the spectacle independence rate was found to be better than with combined EDOF and trifocal IOLs at 12 months but similar to bifocal IOLs at 12 months.[12,32] As reported, the objective intermediate and near vision is excellent with this IOL combination, and this appears to be reflected in postoperative subjective intermediate and near visual function and low requirement for reading spectacles. There does appear to be some early postoperative halos; however, as mentioned above, no patients report to be

Table 4. Comparison of 1-month and 12-month patient experience postoperative data

	Question				
	How often do you require reading spectacles?				
Postop assessment	Never	Occasionally	Quite often	Always	
Postop 1	95.5%	4.5%	0%	0%	
Postop 2	93.2%	6.8%	0%	0%	
	How much difficulty do you have doing a regular task that requires you to see well in the distance?				
	Distance vision is clear	Slight problem	Moderate problem	Severe problem	Intolerable problem
Postop 1					
Activity 1	81.8%	13.6%	4.5%	0%	0%
Activity 2	90.9%	6.8%	2.3%	0%	0%
Postop 2					
Activity 1	93.2%	6.8%	0%	0%	0%
Activity 2	95.5%	4.5%	0%	0%	0%
	How much difficulty do you have doing a regular task that requires you to see well at intermediate working distances?				
	Intermediate vision is clear	Slight problem	Moderate problem	Severe problem	Intolerable problem
Postop 1					
Activity 1	95.5%	4.5%	0%	0%	0%
Activity 2	100%	0%	0%	0%	0%
Postop 2					
Activity 1	97.7%	2.3%	0%	0%	0%
Activity 2	100%	0%	0%	0%	0%
	How much difficulty do you have doing a regular task that requires you to see well at near working distances?				
	Near vision is clear	Slight problem	Moderate problem	Severe problem	Intolerable problem
Postop 1					
Activity 1	97.7%	2.3%	0%	0%	0%
Activity 2	97.7%	2.3%	0%	0%	0%
Postop 2					
Activity 1	95.5%	4.5%	0%	0%	0%
Activity 2	100%	0%	0%	0%	0%
	How were your expectations fulfilled with the procedure?				
	More than fulfilled	Fulfilled	Sufficiently fulfilled	Not fulfilled at all	
Postop 1	45.5%	47.7%	6.8%	0%	
Postop 2	65.9%	34.1%	0%	0%	

very intolerant of halos in this study, and importantly, the annoyance of halos significantly reduces at 12 months, and very high overall QoV scores are reported as patients neuroadapt.

All patients were assessed for stereopsis preoperatively, and to maximize function of this IOL combination, stereopsis must be present preoperatively. This study found that stereopsis was at least maintained or improved in all patients postoperatively, and therefore, this mix-and-match approach has not negatively affected on stereopsis. Contrast sensitivity has been reported to be normal for age-matched patients, and analysis of contrast sensitivity in this study supported that previously found.[19] No eyes required Nd:YAG, and the 4 eyes that required laser enhancement noticed an improvement in visual acuity and subjective outcomes.

A limitation of this current study is that it does not directly compare this complementary IOL combination with the other available multifocal IOLs. However, this study does present the clinical outcomes at 2 postoperative assessments and gives clinical information of how the IOL combination performs objectively and subjectively, and how this alters over a 12-month period after implantation.

In conclusion, this study found that this new complementary IOL combination implantation provides excellent uncorrected vision from distance to near with high postoperative subjective visual function and satisfaction at both postoperative assessments. Refractive and visual outcomes remain stable, and this combination provides a high level of spectacle independence. There does appear to be some early dysphotopsias, particularly halos, which significantly

reduces with time. This IOL combination appears to be an excellent methodology to achieve spectacle independence in lens-based surgery.

WHAT WAS KNOWN

- Combined implantation of EDOF and trifocal IOLs provides a range of clear vision and high postoperative subjective patient satisfaction.

WHAT THIS PAPER ADDS

- A new complementary continuous phase multifocal IOL combination, with one IOL designed for near vision and the other for intermediate vision, provides excellent and similar objective and visual outcomes at 3 months and 12 months postoperatively.
- This combination provides excellent subjective outcomes. Some early dysphotopsias were found postoperatively; however, neuroadaptation occurs between the 2 assessments resulting in superior QoV outcomes at 12 months.

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