ARTICLE

Visual outcome and optical quality after implantation of zonal refractive multifocal and extended-range-of-vision IOLs: a prospective comparison

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Purpose: To compare the visual outcomes and optical quality of 2 presbyopia-correcting intraocular lenses (IOLs) with those of a monofocal IOL.

Settings: Eye Center, the Second Affiliated Hospital of Zhejiang University, School of Medicine, Hangzhou, Zhejiang, China.

Design: Prospective cohort study.

Methods: The study included patients who had cataract surgery and were implanted with a Tecnis Symfony Extended Range of Vision (EROV) IOL (ZXR00), a zonal refractive multifocal IOL (Lentis Comfort LS-313 MF15), or a monofocal IOL (Lentis L-313). Postoperative examinations took place at 1 week, 1 month, and 3 months and included visual acuity at far, intermediate, and near distances, defocus curves, contrast sensitivity, wavefront aberrations, and modulation transfer function (MTF). Patients completed the Visual Function Index questionnaire (VF-14), the Quality of Vision questionnaire (QoV), and a visual quality self-evaluation.

Results: One hundred thirteen patients were enrolled. The EROV and multifocal IOLs achieved a significantly better range of intermediate vergences ($P < .05$), better distance-corrected intermediate visual acuity ($P \leq .001$), higher VF-14 ($P < .05$) and visual quality self-evaluation scores ($P < .05$) than the monofocal IOL, but there were no significant differences between the 2 presbyopia-correcting IOLs. The EROV provided lower total wavefront aberrations and better MTF than the multifocal and the monofocal IOLs ($P < .05$) but demonstrated a worse QoV score ($P < .05$), especially for severity of halo ($P < .01$) and starburst ($P < .05$) symptoms.

Conclusions: Both the Tecnis Symfony ZXR00 and the Lentis Comfort LS-313 MF15 offered excellent visual restoration and stable distance and intermediate visual acuity, good subjective visual function, and good contrast sensitivity. The EROV IOL provided better objective optical quality and more prominent dysphotopsia symptoms than the multifocal IOL.

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Cataract is a major cause of blindness, especially in developing countries. Monofocal intraocular lenses (IOLs) were developed to replace the opaque lens and are capable of providing good distance vision while losing accommodative ability. In the past decades, the introduction of multifocal IOLs, based on the principles of either diffraction or refraction, have provided good vision at near and far distances, but intermediate vision is not sufficient.[1,2] However, computer work and daily life activities have increased patient demand for simultaneous intermediate vision.

In recent years, new optical designs have become available to solve those problems. The Lentis Comfort LS-313 MF15 (Oculentis BV) is a rotationally asymmetric IOL with a refractive design, combining an aspheric distance vision zone with a +1.50 diopter (D) add sector-shaped near vision zone.[3] The reduced add power was developed to increase intermediate visual acuity and decrease optical phenomena. Another new-concept IOL, the Tecnis Symfony Extended Range of Vision (EROV) ZXR00 IOL (Johnson & Johnson Vision), based on a proprietary achromatic diffractive echelette design, reportedly

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generates an EROV and a minimal level of disturbing photic phenomena.[4,5]

The aim of this study was to compare the visual outcomes and photic phenomena between the Tecnis Symfony ZXR00 and the Lentis Comfort IOLs.

METHODS

Study Design

This single-center prospective, nonrandomized, participant- and examiner-blinded cohort study was performed with the approval of the Institutional Review Board of the Second Affiliated Hospital of the School of Medicine, Zhejiang University, Hangzhou, China, and in accordance with the tenets of the Declaration of Helsinki. Written informed consent was obtained from all patients after they received a full explanation of the study. This trial was registered at www.chictr.org.cn (identification number ChiCTR-ONC-17011119).

Patients

This trial included patients undergoing cataract surgery between September 2016 and February 2018 at Eye Center, Second Affiliated Hospital, College of Medicine, Zhejiang University. Inclusion criteria were aged from 50 to 85 years, no active ocular disease except cataracts, nonsevere dry eye, angle κ within 0.5 mm, no pupillary abnormality, and no surgery within 3 months. Exclusion criteria were reduced zonular/capsular stability, corneal astigmatism higher than 1.25 D, previous refractive surgery, poor mobility, IOL dislocation, posterior capsule opacification, or any ocular comorbidity (amblyopia, retina, or optic nerve pathology) that may hamper postoperative acuity.

All patients had a comprehensive preoperative ophthalmologic examination that included the measurement of uncorrected distance visual acuity, optical biometry (IOL Master, Carl Zeiss Meditec AG), slitlamp examination, tonometry (NT-510, Nidek Co., Ltd.), corneal topography by Scheimpflug imaging (Pentacam, Oculus Optikgeräte GmbH), and dilated fundoscopy.

Patients who met the above criteria were adequately informed about the nature and possible consequences of the study and the characteristics of the IOLs before they chose IOL types. Patients were consecutively enrolled after signing consent forms with the exception of dropout replacements. Patients were recommended for bilateral implantation of the same IOL type.

Surgical Technique

IOL power was chosen to target emmetropia ± 0.5 D. Phacoemulsification surgeries were performed by 4 experienced surgeons (K.Y., W.X., X.S., P.C.), each having had experience with more than 10 000 cases of cataract surgery, using the standard protocol. After topical anesthesia was administered, a 2.0 mm single-plane main incision and a 0.8 mm side-port corneal incision were made with a keratome. A 5.0 mm continuous curvilinear capsulorhexis was performed. Phacoemulsification was performed using a standard stop-and-chop technique with the Stellaris system in all patients. All procedural characteristics were consistent. The sectorial refractive of the LS-313 MF15 IOL was inferiorly positioned. The patients were treated postoperatively with the standard of care.

Intraocular Lenses

The Tecnis Symfony EROV ZXR00 is a single-piece, ultraviolet (UV)-filtering, open-loop haptic, hydrophobic acrylic folding IOL with an overall diameter of 13.0 mm and an optic diameter of 6.0 mm (Figure 1). It has an achromatic echelette design that promotes an extended focus range by splitting light energy into an elongated focus, with a posterior diffractive surface and aspheric (−0.27 μm) anterior face to compensate the positive corneal spherical aberration.[6]

The Lentis Comfort LS-313 MF15 is a foldable, single-piece, UV-absorbing, plate-haptic IOL with an overall length of 11.0 mm and a biconvex optic diameter of 6.0 mm (Figure 1). It is a hydrophilic acrylic material with a hydrophobic surface. It is a rotationally asymmetric IOL with a refractive design, combining an aspheric aberration-free (0.0 μm) distance vision zone with a sector-shaped near vision zone with a +1.50 D add power.[3]

The Lentis L-313 is an aspheric monofocal IOL based on the same platform as the LS-313 MF15 IOL without the sector-shaped near vision zone. It is a foldable, single-piece, UV-absorbing, hydrophilic, plate-haptic, aspheric aberration-free (0.0 μm), monofocal IOL with an overall length of 11.0 mm and a biconvex optic diameter of 6.0 mm.

Outcome and Assessment

All patients (113 patients [114 eyes]) were evaluated 1 week, 1 month, and 3 months postoperatively in accordance with routine clinical care policies for patients having cataract surgery. Each measurement was taken by the same ophthalmic technicians who performed a certain postoperative functional examination blinded to the identity of the IOL implanted.

Visual acuity was measured at each visit. Monocular uncorrected and corrected visual acuity was measured at far (5 m), intermediate (80 cm), and near (40 cm) distances. Distance-corrected visual acuity was measured at intermediate (80 cm) and near (40 cm) distances. In addition, a monocular defocus curve was tested from −4.0 to +2.0 D in 0.5 D increments.

Contrast sensitivity with or without glare under mesopic conditions was measured using a vision contrast sensitivity test (Vistech Consultants, Inc.) based on best near-corrected status. An optic path difference aberrometry scan (OPD Scan II; Nidek Co., Ltd.) was completed at a 3.0 mm and 5.0 mm pupil diameter using 0.5% tropicamide eye drops.

The Visual Function Index (VF-14) questionnaire, Quality of Vision questionnaire (QoV), and visual quality self-evaluation were completed at the last visit.[7–9] The Chinese-translated VF-14 assesses the functional capabilities of patients based on 14 uncorrected vision–dependent daily activities, scoring each item in relation to the degree of difficulty as follows: no difficulty (4), a little difficulty (3), a moderate amount of difficulty (2), or a great deal of difficulty doing the task (1), or inability to do the task (0). Items were not included in the scoring if patients could

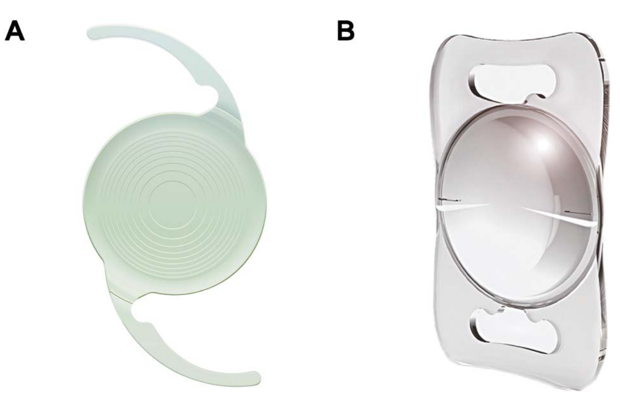

Figure 1. *A*: Extended-range-of-vision IOL (AMO [Shanghai] (Image courtesy of Medical Devices Trading Co., Ltd.) and (*B*) rotational asymmetric refractive IOL with +1.50 D inferior sector-shaped add (Image courtesy of Gaush Jingpin Ltd.) (IOL = intraocular lens).

not perform the activity for reasons other than vision-related.[10] Scores on all activities were averaged, and the mean score was then multiplied by 25. The resulting VF-14 score ranged from 0 (worst functional impairment) to 100 (no disability).[11] The QoV is a validated, Rasch-adjusted questionnaire in which patients are asked to rate 10 dysphotopsia items illustrated by standard photographs, scoring each item (0, 1, 2, and 3; higher score means worse photic phenomena) in relation to how frequent, severe, and bothersome their symptoms are (33 items in total). The visual quality self-evaluation score ranges from 0 (worst) to 10 (perfect) at daytime or night.

Statistical Analyses

Data are presented as the mean ± SD. Statistics were analyzed using SPSS for Mac software and SPSS Statistics for Windows software (version 22.0, IBM Corp.). Normality of data distribution was assessed using the Shapiro–Wilks test. Homogeneity of variances was assessed using the Levene test. Analysis of variance or the Kruska-Wallis test with multiple post hoc comparisons was used to compare the outcomes among different IOL groups. Comparisons between clusters of patients with different IOLs implanted were evaluated with the independent sample *t* test or the nonparametric Mann-Whitney *U* test. Two-sided *P* values less than .05 were considered statistically significant.

RESULTS

Demographic data of patients enrolled in each group are presented in Table 1 along with preoperative clinical data. There were no statistically significant differences in age, sex, IOL power, preoperative uncorrected distance visual acuity (UDVA), corneal endothelial cell count, corneal astigmatism, angle κ, and axial length among the 3 groups.

Postoperative monocular visual acuity was measured 1 week, 1 month, and 3 months postoperatively. There was no statistically significant change in uncorrected visual acuities within each group at each visit ($P > .50$) (Table 2).

At the 3-month visit, the presbyopia-correcting groups achieved significantly better distance-corrected intermediate visual acuity (DCIVA) than the L-313 group at each visit ($P = .018$, LS-313 MF15 vs L-313; $P = .001$, ZXR00 vs L-313; respectively), whereas no significant difference was exhibited between them ($P = .928$, ZXR00 vs LS-313 MF15). Uncorrected and best-corrected visual acuities, DCNVA, sphere, cylinder, and spherical equivalent exhibited no significant difference among those 3 groups (Table 3).

Figure 2 presents the monocular defocus curves for the 3 groups for comparison at each visit. Both presbyopia-correcting IOL groups showed significantly better intermediate vision than the L-313 group, providing a range of stable proper vision (0.3 logarithm of the minimum angle of resolution [logMAR] or better) from infinity to 50 cm (−2.0 D). The ZXR00 group showed a nonsignificant trend in better and smoother extended range of intermediate vergences compared with the LS-313 MF15 group, whereas the LS-313 MF15 group showed a nonsignificant trend in better near vision.

Figure 3 shows the mean contrast sensitivity function obtained in the group of eyes evaluated with or without glare under mesopic conditions at 3 months postoperatively. As shown, there were no statistically significant differences among the 3 IOL groups either in glare or nonglare conditions.

Aberrometry scans were completed at the 3-month visit. At both a 3.0 mm and 5.0 mm diameter pupil, the ZXR00 group achieved a significantly lower total aberration and higher spherical aberrations and Strehl ratio compared with the LS-313 MF15 group and the L-313 group. The total higher-order aberration in the ZXR00 group was not significantly different from that in the L-313 group at a 3.0 mm and 5.0 mm pupil, whereas it was significantly lower than that in the LS-313 MF15 group at a 5.0 mm pupil. For a 3.0 mm and 5.0 mm pupil, the total higher-order aberration in the LS-313 MF15 group was significantly higher than that in the L-313 group, whereas there was no statistically significant difference in the Strehl ratio and spherical aberrations (Table 4).

The modulation transfer function (MTF) decreased as the spatial frequency increased at both a 3.0 mm and 5.0 mm pupil diameter. The ZXR00 group achieved significantly better MTF than the LS-313 MF15 group and

Table 1. Preoperative patient demographics.

Parameter	Mean ± SD			
	L-313	LS-313 MF15	ZXR00	*P* Value
No. of eyes (patients)	47 (36)	47 (34)	47 (34)	
Age (yr)	68.56 ± 8	69.72 ± 7.89	69.57 ± 8.44	.758
Sex				.331
Male (n)	19	19	13	
Female (n)	28	28	34	
IOL power (D)	20.46 ± 1.94	20.79 ± 1.98	21.16 ± 1.49	.150
UDVA (logMAR)	0.66 ± 0.40	0.64 ± 0.38	0.63 ± 0.34	.972
Corneal endothelial cell count (/mm)	2635 ± 177	2546 ± 247	2542 ± 226	.069
Corneal astigmatism (D)	0.63 ± 0.29	0.59 ± 0.24	0.58 ± 0.24	.438
Angel κ (mm)	0.23 ± 0.13	0.19 ± 0.09	0.20 ± 0.11	.411
Axial length (mm)	23.63 ± 1.04	23.34 ± 0.97	23.58 ± 0.69	.222

IOL = intraocular lens; logMAR = logarithm of the minimum angle of resolution; UDVA = uncorrected distance visual acuity

Table 2. Repeated measurements of uncorrected visual acuities after IOL implantation.

IOL	Postoperative Visit (logMAR, mean ± SD)			*P* Value
	1 wk	1 mo	3 mo	
UDVA				
ZXR00	0.12 ± 0.16	0.12 ± 0.14	0.1 ± 0.13	.878
LS-313 MF15	0.18 ± 0.16	0.18 ± 0.16	0.12 ± 0.13	.051
L-313	0.19 ± 0.21	0.17 ± 0.2	0.15 ± 0.17	.609
UIVA				
ZXR00	0.19 ± 0.15	0.18 ± 0.16	0.14 ± 0.12	.262
LS-313 MF15	0.17 ± 0.15	0.18 ± 0.2	0.16 ± 0.17	.798
L-313	0.22 ± 0.23	0.117 ± 0.18	0.2 ± 0.18	.776
UNVA				
ZXR00	0.41 ± 0.19	0.34 ± 0.19	0.34 ± 0.19	.094
LS-313 MF15	0.31 ± 0.23	0.3 ± 0.21	0.32 ± 0.18	.683
L-313	0.45 ± 0.20	0.41 ± 0.2	0.38 ± 0.16	.052

IOL = intraocular lens; logMAR = logarithm of the minimum angle of resolution; UDVA = uncorrected distance visual acuity; UIVA = uncorrected intermediate visual acuity; UNVA = uncorrected near visual acuity

L-313 group from 5 to 60 cpd (*P* < .001). The LS-313 MF15 group showed a nonsignificant trend of lower MTF than the L-313 group (Figure 4).

Participants received questionnaire evaluations on their last visit (Table 5). The percentage of cases achieving a VF-14 score of 90 or higher were measured. The ZXR00 group and LS-313 MF15 group achieved a better VF-14 result than the L-313 group, although statistical significance was only seen in the LS-313 MF15 group (*P* < .05), whereas there were no significant differences between the two presbyopia-correcting IOLs. The score of visual quality self-evaluation in the ZXR00 group was significantly better than the L-313 group in the daytime (*P* < .05), whereas the LS-313 MF15 group was significantly better than the L-313 group at night (*P* < .05). There were no significant differences between the ZXR00 group and the LS-313 MF15 group. The total score of QoV was significantly higher in the ZXR00 group than in the other 2 groups (Table 5), and the glare and starbursts were severer in the ZXR00 group than in the other 2 groups, whereas there was no significant difference of glare severity among those 3 groups (Figure 5). ZXR00 had a significantly higher score in focusing difficulty, whereas LS-313 MF15 had a significantly higher score in hazy vision than ZXR00 groups (Supplemental Table 1, Supplemental Digital Content 1, available at http://links.lww.com/JRS/A19).

DISCUSSION

Currently, the use of computers and other devices that necessitate reading requires optimal visual acuity for intermediate distance, but most multifocal IOLs only provide acceptable visual acuity for distance and near vision.

Table 3. Visual acuities and refractive outcomes 3 months after IOL implantation.

Parameter	Mean ± SD			Comparison	*P* Value
	L-313	LS-313 MF15	ZXR00		
UDVA (logMAR)	0.15 ± 0.17	0.12 ± 0.13	0.10 ± 0.13		.174
UIVA (logMAR)	0.20 ± 0.18	0.16 ± 0.17	0.14 ± 0.12		.378
UNVA (logMAR)	0.38 ± 0.16	0.32 ± 0.18	0.34 ± 0.19		.164
CDVA (logMAR)	−0.01 ± 0.08	0 ± 0.05	-0.01 ± 0.07		.505
CIVA (logMAR)	0.04 ± 0.11	0.03 ± 0.07	0.02 ± 0.10		.79
CNVA (logMAR)	0.06 ± 0.11	0.08 ± 0.11	0.09 ± 0.20		.508
DCIVA (logMAR)	0.21 ± 0.14	0.14 ± 0.11	0.11 ± 0.13		.001***
				ZXR00 vs LS	.928
				ZXR00 vs L-313	.001***
				LS vs L-313	.018*
DCNVA (logMAR)	0.44 ± 0.16	0.36 ± 0.15	0.37 ± 0.17		.091
Sphere (D)	0.05 ± 0.92	0.05 ± 0.77	0.04 ± 0.53		.533
Cylinder (D)	−0.54 ± 0.66	−0.55 ± 0.43	−0.52 ± 0.57		.387
SE (D)	−0.21 ± 0.61	−0.23 ± 0.69	−0.21 ± 0.87		.992

CDVA = corrected distance visual acuity; CIVA = corrected intermediate visual acuity; CNVA = corrected distance visual acuity; DCIVA = distance-corrected intermediate visual acuity; DCNVA = distance-corrected near visual acuity; IOL = intraocular lens; logMAR = logarithm of the minimum angle of resolution; SE, spherical equivalent; UCVA = uncorrected distance visual acuity; UDVA = uncorrected distance visual acuity; UIVA = uncorrected intermediate visual acuity; UNVA = uncorrected near visual acuity
**P* < .05, ***P* < .01.

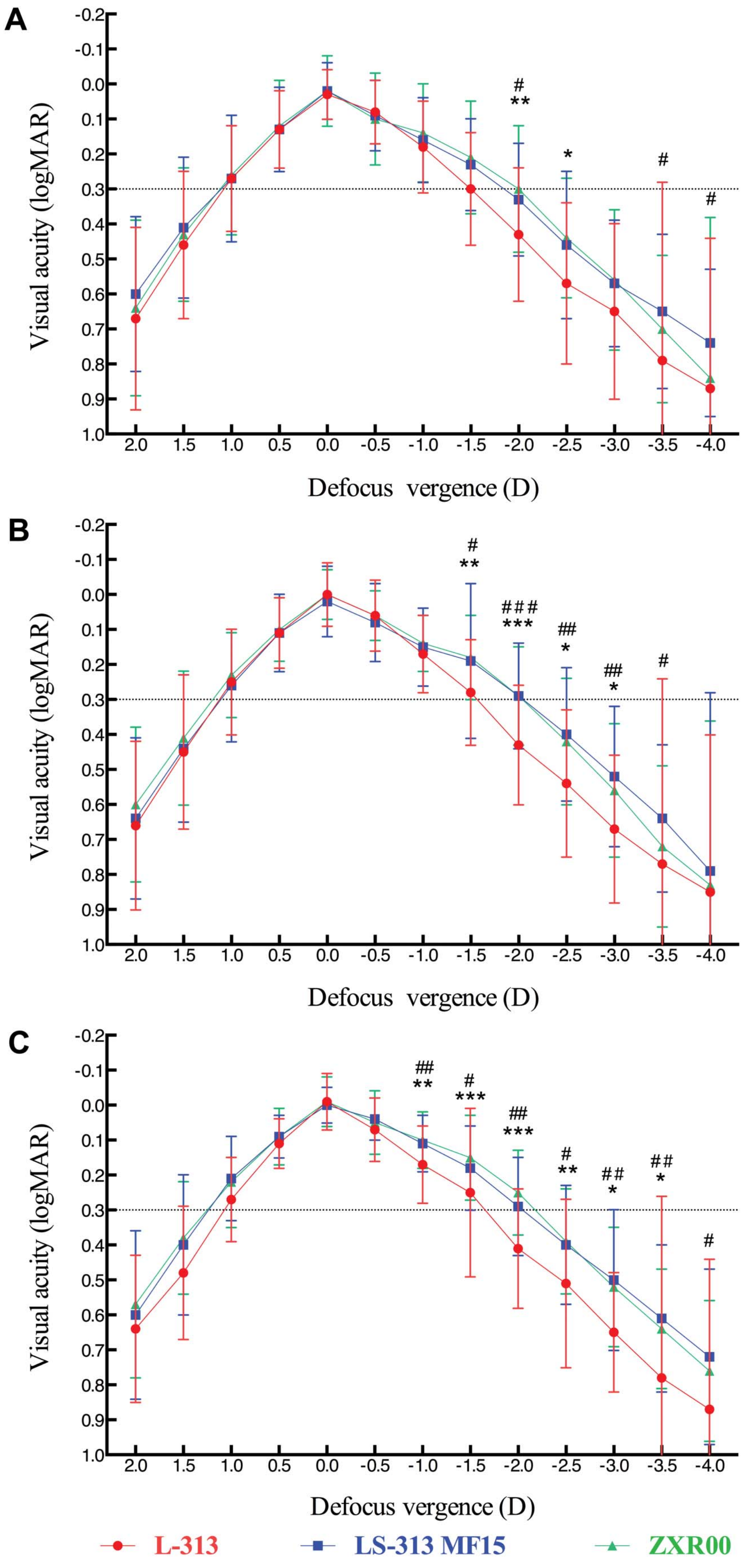

Figure 2. Mean monocular defocusing curves in the 3 groups at 1 week (*A*), 1 month (*B*), and 3 months (*C*). *P < .05, **P < .01, ***P < .001, ZXR00 vs L-313; #P < .05, ##P < .01, ###P < .001, LS-313 MF15 vs L-313 (logMAR = logarithm of the minimum angle of resolution).

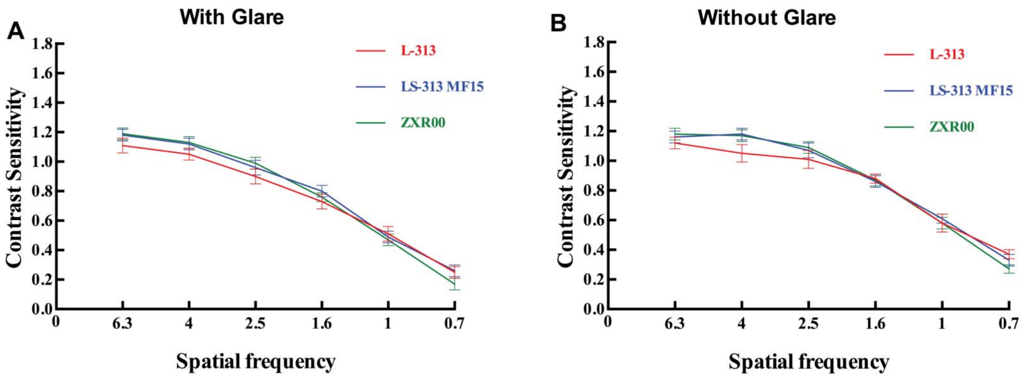

Figure 3. Contrast sensitivities with (A) and without (B) glare under mesopic conditions 3 months after IOL implantation.

Trifocal IOLs, although they only distribute 15% of light energy for intermediate vision, partly compensate the limitation.[12–14] To our knowledge, this is the first study to compare the visual outcomes of the Symfony EROV ZXR00 and Lentis Comfort LS-313 MF15, which aimed to provide optimal intermediate vision.

The visual performance was stable at each visit, and clinical outcomes were shown at 3 months postoperatively.

Table 4. Aberrations 3 months after IOL implantation (RMS, mean ± SD).

	Mean ± SD				
Parameter	L-313	LS-313 MF15	ZXR00	Comparison	*P* Value
3.0 mm pupil diameter	n = 44	n = 45	n = 37		
Total aberration	0.61 ± 0.22	0.72 ± 0.30	0.49 ± 0.40		>.001***
				ZXR00 vs LS	<.001***
				ZXR00 vs L-313	.002**
				LS vs L-313	.185
tHOA	0.13 ± 0.07	0.15 ± 0.06	0.16 ± 0.10		.026*
				ZXR00 vs LS	1
				ZXR00 vs L-313	.129
				LS vs L-313	.033*
Total spherical aberration	0.01 ± 0.01	0.01 ± 0.01	0.03 ± 0.02		<.001***
				ZXR00 vs LS	<.001***
				ZXR00 vs L-313	<.001***
				LS vs L-313	1
Strehl ratio	0.02 ± 0.03	0.02 ± 0.03	0.06 ± 0.06		<.001***
				ZXR00 vs LS	<.001***
				ZXR00 vs L-313	<.001***
				LS vs L-313	.358
5.0 mm pupil diameter	n = 43	n = 42	n = 32		
Total aberration	1.62 ± 0.62	2.00 ± 0.82	1.09 ± 1.10		<.001***
				ZXR00 vs LS	<.001***
				ZXR00 vs L-313	<.001***
				LS vs L-313	.04*
tHOA	0.40 ± 0.19	0.58 ± 0.19	0.56 ± 0.63		<.001***
				ZXR00 vs LS	.035*
				ZXR00 vs L-313	.346
				LS vs L-313	<.001***
Total spherical aberration	0.10 ± 0.06	0.08 ± 0.06	0.19 ± 0.09		<.001***
				ZXR00 vs LS	<.001***
				ZXR00 vs L-313	<.001***
				LS vs L-313	1
Strehl ratio	0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.01		<.001***
				ZXR00 vs LS	<.001***
				ZXR00 vs L-313	<.001***
				LS vs L-313	.245

IOL = intraocular lens; RMS = root mean square; tHOA = total high-order aberration

*P < .05, **P < .01, ***P < .001.

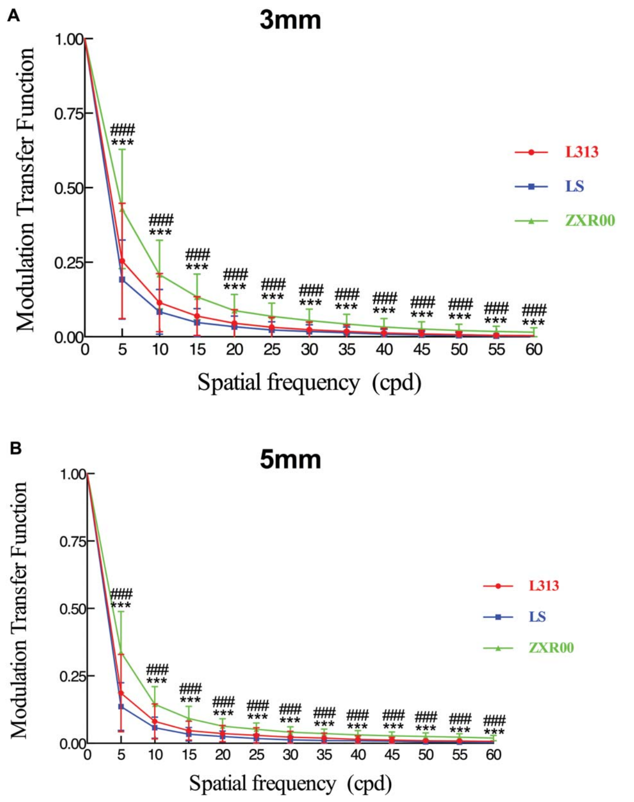

Figure 4. Modulation transfer function at a 3.0 mm (*A*) and 5.0 mm (*B*) pupil diameter 3 months after intraocular lens implantation (###*P* < .001; ****P* < .001) (cpd = cycle per degree.

There was no significant difference between LS-313 MF15 and Symfony ZXR00 in corrected or uncorrected vision from far distances to near distances. The postoperative mean spherical equivalent of each group was within ±0.5 D, consistent with emmetropia target. Although mean postoperative astigmatism and sphere were within ±0.75 D and not significantly different among groups, corrected distance visual acuity is a proper way to show IOL visual function because of the existence of refractive error.[11,15,16] The LS-313 MF15 and ZXR00 showed excellent DCIVA (better than 0.15 logMAR), significantly better than L-313, predicting better intermediate vision. Pedrotti et al.[15] showed a similar result that ZXR00 provided significantly better binocular DCIVA than the monofocal IOL. Studies of Yoo et al.[17] and Kretz et al.[3] showed LS-313 MF15 provided good performance for monocular and binocular intermediate distances, similar to our study. However, DCNVA demonstrated that ZXR00 failed to cover near vision in our study (0.37 ± 0.17 logMAR), similar to the result by Mencucci et al.[18].

The defocus curves demonstrated that ZXR00 and LS-313 MF15 provided successful visual restoration at all distances, providing excellent visual acuity from 0 to −2.0 D (distance to 50 cm). Also, there were no differences of refractive stabilization during the neuroadaptation process between groups. These 2 presbyopia-correcting IOLs performed significantly better than L-313 at each visit, especially at 3 months. The research of Kretz et al.,[3] Pedrotti et al.,[15] Escandon-Garcia et al.,[6] and Ganesh et al.[19] showed that LS-313 MF15 and ZXR00 provide 0.3 logMAR or better visual acuity from 0 to −2.0 D, which is consistent with our study.

There were no statistically significant differences in contrast sensitivity among the three IOL groups, either in glare or nonglare conditions under best-corrected distance vision. Previous studies showed that ZXR00 achieved excellent contrast sensitivity compared with other multifocal IOLs[6,18,20] and monofocal IOLs,[21] whereas little

Table 5. Subjective evaluation by questionnaires 3 months after IOL implantation.

Parameter	L-313	LS-313 MF15	ZXR00	Comparison	*P* Value
VF-14 score > 90 (%)	48.9	78.7	61.7		.012*
				LS vs L-313	.005**
				ZXR00 vs L-313	.3
				LS vs ZXR00	.114
Visual quality self-valuation (mean ± SD)					
Day score	8.68 ± 1.03	8.98 ± 1.26	9.19 ± 1.25		.029*
				LS vs L-313	.220
				ZXR00 vs L-313	.028*
				LS vs ZXR00	1
Night score	8.36 ± 1.16	8.90 ± 1.37	8.66 ± 1.43		.027*
				LS vs L-313	.023*
				ZXR00 vs L-313	.318
				LS vs ZXR00	.877
QoV score (mean ± SD)	1.83 ± 3.03	3.98 ± 6.99	5.66 ± 6.06		0
				LS vs L-313	.81
				ZXR00 vs L-313	.01*
				LS vs ZXR00	.034*

IOL = intraocular lens; QoV = Quality of Vision questionnaire; VF-14 = Visual Function Index questionnaire
**P* < .05, ***P* < .01, ****P* < .001.

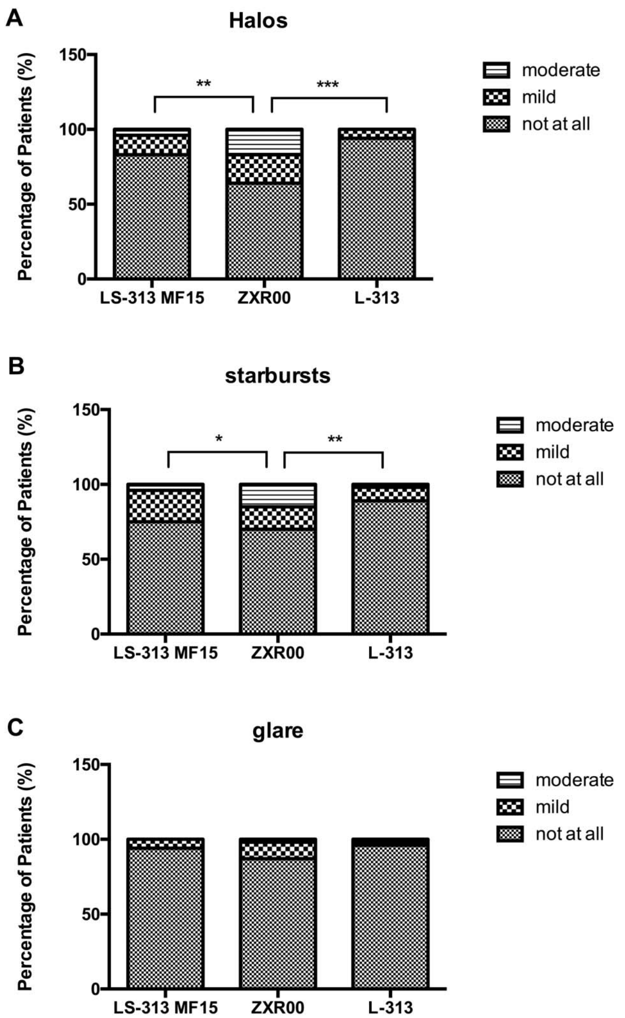

Figure 5. Severity of halo (*A*), starbursts (*B*), and glare (*C*) in the Quality of Vision questionnaire. $^{*}P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$.

research studied LS-313 MF15's contrast sensitivity in vivo.

The objective optical quality was measured at a 3.0 mm and 5.0 mm pupil diameter, monitoring the pupil aperture under bright or dark conditions.[22] Our study showed that ZXR00 achieved higher positive residual total ocular sphere aberration, might provide a positive contribution to improving the depth of focus, and the tolerance to defocus.[23–25] The ZXR00 group achieved significantly lower total aberrations, higher Strehl ratio, and significantly higher MTF values from a 5 to 60 cpd spatial frequency than the LS-313 MF15 group and the L-313 group, meaning that in vivo, better measured visual quality was provided by the Symfony IOL. This might be benefitting from its proprietary achromatic diffractive echelette design. A study by Millan et al. showed that Symfony ZXR00 provided remarkable chromatic compensation in vitro, but further clinical measurements and studies were needed to qualify the chromatic aberrations.[26]

The questionnaire results indicated subjective visual function outcomes. The VF-14 was designed and used to measure functional impairment and treatment outcomes in a myriad of ocular conditions, including cataracts, and a score of 90 or higher was considered to be a satisfactory subject function outcome postoperatively.[10,27,28] Both the ZXR00 group and the LS-313 MF15 group achieved a better VF-14 result than the L-313 group, although statistical significance was only seen in the LS-313 MF15 group, demonstrating provision of a better subject function outcome.

The QoV used standard photographs to illustrate each symptom, helping to promote good item separation and a greater consistency of understanding between respondents for the individual dysphotopsia items scored.[7,8] Association with a high incidence of photic phenomena, such as halos, glares, and starbursts, was the main reason for patients' dissatisfaction after multifocal IOL implantations. In our study, no severe cases appeared, but the total QoV score was significantly higher in the ZXR00 group, which indicated a higher frequency of or worse dysphotopsia symptoms. The ZXR00 IOL resulted in severer halos and starbursts compared with the LS-313 MF15 IOL and monofocal IOL, whereas glare was not significantly different among groups. Pedrotti et al. showed that the glare level of the ZXR00 IOL was no different from that of the monofocal IOL, similar to our study.[15] A recent study showed that the ZXR00 IOL micromonovision design may have resulted in a higher percentage of noticeable dysphotopsia in patients as a trade-off for a higher degree of functional near vision.[19] Compared with the L-313 group, the ZXR00 group achieved better self-reported visual quality results during the daytime, whereas the LS-313 MF15 group was better at night. The ZXR00 group gave better objective results and subjective day visual quality and might benefit from Symfony's achromatic echelette design. However, the zonal refractive IOL which had a smoother transition zone was less likely to develop dysphotopsia symptoms than the diffractive IOL at night, which might have impact on patients' subjective self-evaluation.

One limitation of our study was not having a randomized design, as patients were divided according to their personal preference. Another limitation was that surgery would not be performed on the other eye if it only had mild cataracts, and a few patients had personal scruples related to receiving bilateral surgery in a short time interval.

In conclusion, both the Symfony (EROV) ZXR00 and Lentis Comfort LS-313 MF15 are good surgical options for cataract surgery and offer a restored excellent and stable distance and intermediate visual acuity, as well as good contrast sensitivity. The Symfony ZXR00 IOL provides better objective visual quality. Dysphotopsia symptoms, especially halos and starbursts, were more prominent in the ZXR00 groups, whereas hazy vision only appeared in the LS-313 MF15 group. Although dysphotopsia symptoms appeared mild, patients scheduled for these 2 presbyopia-correcting IOL implantations should continue to be counseled about these effects preoperatively.

WHAT WAS KNOWN

- Diffraction and refraction are major optical design principles for multifocal intraocular lenses (IOLs). The major limitations of multifocal IOLs are contrast sensitivity deterioration, dysphotopsia symptoms, and the inability to provide satisfactory vision at an intermediate distance.
- The Lentis Comfort LS-313 MF15 and the Tecnis Symfony Extended Range of Vision ZXR00 were two new-concept presbyopia-correcting IOLs designed to meet the demand for simultaneous intermediate vision.

WHAT THIS PAPER ADDS

- Both the LS-313 MF15 IOL and Symfony ZXR00 IOL provided significantly better intermediate visual outcomes than the monofocal IOL, with comparable distance visual acuity and good quality of vision levels. Both presbyopia-correcting IOL models seemed to be a good option for patients with intermediate-vision requirements.
- Dysphotopsia symptoms, although appearing mild, were more prominent after Symfony ZXR00 IOL implantation than after LS-313 MF15 or monofocal IOL implantation.

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