Original Article

Visual outcomes of binocular implantation of a new extended depth of focus intraocular lens

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Purpose: To evaluate the visual outcomes of bilateral implantation of a new hydrophobic foldable extended depth of focus (EDOF) IOL. **Methods:** All cases undergoing phacoemulsification with bilateral implantation of Supraphob Infocus IOL between December 2017 and July 2018 at a tertiary eye care center were recruited in this prospective interventional study. The primary outcome measures were uncorrected distance visual acuity (UDVA), uncorrected intermediate visual acuity (UIVA), and uncorrected near visual acuity (UNVA). Postoperative follow-up was done on day 1, 1 week, 1 month, and 3 months. **Results:** One hundred and four eyes of 52 patients with a mean age of 58.4 ± 9.3 years were included. The mean UDVA improved from 0.84 ± 0.32 logMAR preoperatively to 0.11 ± 0.08 logMAR at 3 months following surgery. At the final follow-up, the binocular UDVA, UIVA, and UNVA was 0.03 ± 0.07, 0.14 ± 0.06, and 0.36 ± 0.05 logMAR, respectively. The mean CS was 1.47 ± 0.06 logCS. The distance and near stereopsis was 90.2 ± 24.8 s of arc (arcsec) and 62.5 ± 19.4 arcsec, respectively. The mean total higher-order aberration (HOA), point spread function, and modulation transfer function were 0.30 ± 0.13, 0.07 ± 0.08, and 0.26 ± 0.07, respectively. **Conclusion:** The Supraphob Infocus EDOF IOL provides good unaided visual acuity for distance, intermediate, and near along with a high quality of vision as assessed by contrast sensitivity, HOAs, and stereoacuity. It may be a potential alternative to the currently available EDOF IOLs in providing good visual acuity at variable distances.

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Cataract surgery and intraocular lenses (IOLs) are constantly evolving with the advances in technology. Premium IOLs in the form of toric and multifocal implantation following cataract surgery have drastically reduced the dependence of patients on spectacles making cataract surgery akin to refractive surgery.[1]

Monofocal IOLs target for a clear distance vision. Visual requirements for near with monofocal IOLs can be met only with monovision correction; however, this may cause a certain level of suppression and loss of stereopsis, which may compromise the ultimate binocular visual outcome.[2] To resolve this problem, "presbyopia-correcting IOLs" were designed. This includes multifocal (bifocal and trifocal), accommodative, or pseudo-accommodative, and extended depth of focus (EDOF) IOLs.[3,4]

Multifocal IOLs commonly offer one or two additional focusing distances for near and intermediate vision. However, they are associated with dysphotic symptoms of haloes and glare with reduced mesopic and scotopic contrast sensitivity.[5] Accommodative IOL designs achieve good vision at various distances by changing the optical power of the eye by either forward or backward axial movement of the IOL or flexibility in lens thickness or shape.[6] However, these IOLs are mostly out of clinical practice considering the poor long-term visual outcomes due to the associated posterior capsular opacification (PCO) and capsular contraction resulting in asymmetric vaulting and lens tilt.[6] The EDOF IOLs, since its introduction in 2016, have gained enormous popularity as a suitable alternative to the currently available presbyopia-correcting IOLs.[7] They work on the principle of creating a single elongated focal point, enhancing the range of vision. Various designs of EDOF IOLs have been described –Pinhole (IC-8/Xtrafocus Pinhole Implant), echellete, or diffractive (TECNIS Symfony) and refractive IOLs (WIOL-CF/Comfort LS-313/MF15/Mini well).[3,4,8] At present, TECNIS Symfony IOL (Abbott Medical Optics, Inc. of Santa Ana, California) is the only FDA approved EDOF IOL.[7]

Supraphob Infocus IOL (Appasamy associates, Chennai, India) is a new hydrophobic acrylic EDOF IOL with yellow chromophore. This prospective interventional study aims to evaluate the safety and efficacy of the Supraphob Infocus IOL in patients undergoing cataract surgery in both eyes.

Methods

A prospective interventional study was conducted at a tertiary eye care center between December 2017 and November 2018. The study was approved by the institutional review board. The study adhered to the tenets of the Declaration of Helsinki. Written informed consent was obtained from all patients.

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Fifty-five patients with visually significant bilateral cataract, age >40 years, corneal astigmatism <1D, IOL power between 15D to 25D, and willing for follow-up were recruited. Cases with any associated ocular comorbidity or history of ocular surgery were excluded. All cases underwent detailed clinical examination including visual acuity UDVA (uncorrected distance visual acuity) (ETDRS chart- 4 m), UIVA (uncorrected intermediate visual acuity) (Sloan chart- 66 cm), UNVA (uncorrected near visual acuity) (Jaeger's chart at 33 cm and ETDRS chart for near), CDVA (corrected distance visual acuity), manifest refraction, slit-lamp biomicroscopy, intraocular pressure (IOP) (NT-530P Non-contact tonometer, Nidek Technologies), distance and near stereoacuity (Frisby-Davis distance (FD2) stereoacuity test and Randot SO-002, Stereo Opticals Co Inc, Chicago, IL), ocular aberrometry on iTrace (Tracey Technologies, Houston, Tx), specular microscopy (SP 3000P, Topcon Medical Systems, Inc.) and dilated fundus examination. IOL master 500 (Carl Zeiss, Meditec AG) were used for optical biometry, and the SRK-T formula was used for obtaining the IOL power. All patients were targeted for emmetropia.

All patients underwent phacoemulsification surgery by a single surgeon under topical anesthesia. The second eye was operated after a gap of 1 month. Phacoemulsification was performed on the Centurion Vision System (Alcon Laboratories Inc., Fort Worth, TX, USA) through a 2.2 mm incision. The incision was enlarged to 2.8 mm for implantation of Supraphob Infocus IOL (Appasamy associates, Chennai, India). Postoperatively topical prednisolone phosphate 1% QID and moxifloxacin hydrochloride 0.5% TDS were prescribed for 1 month and tropicamide 1% BD for 1 week.

Follow-up was done on day 1, 1 week, 1 month, and 3 months after surgery. Visual acuity, contrast sensitivity, aberrometry, specular microscopy, and stereoacuity was performed at each follow-up.

Supraphob infocus IOL

It is a hydrophobic acrylic EDOF IOL with yellow chromophore. Its anterior surface has a refractive pinhole design. The posterior surface has a 360-degree enhanced square edge design with an aspheric optic. Its overall diameter is 13 mm with an optic size of 6 mm. It has a central zone of 1.2 mm diameter that has a nano diffractive optics primarily for near and intermediate vision with an additional power of 3.5D to focus the objects between 33 cm to 80 cm. Light rays passing through an area 0.3 μ below the edge of this central zone undergo an inward bend eliminating the light scatter, which reduces the chances of glare. Light rays passing between 1.21 mm and 4.75 mm from the center of the optic focus distant objects and provide a clear distance vision. The haptic has a 0° angulation. Its refractive index is 1.5045. The A constant is 118.8, and the IOL is available in the range of +7.0D to +30.0D with increments of 0.5D [Fig. 1].

Visual acuity

The uncorrected distance visual acuity (UDVA) was assessed with ETDRS chart at 4 m, uncorrected intermediate visual acuity (UIVA) with Sloan's chart at 66 cm and uncorrected near visual acuity (UNVA) with Snellen's near vision chart and logarithmic visual acuity chart 2 (Scrambled lines from ETDRS original and ETDRS 2000 series) at 33 cm. Monocular visual acuity was recorded at each visit and binocular visual acuity at final follow-up. Visual acuity values were converted to logMAR for final analysis.

Defocus curve

The patients were asked to binocularly focus on the ETDRS chart at 4 m after correcting for distance vision. Minus lenses were added starting from 0.5D to 3D in steps of 0.5D. The visual acuity for the corresponding value of induced defocus was noted. Similar steps were repeated with plus lenses from 0.5D to 2D in steps of 0.5D. The obtained values of visual acuity for the corresponding defocus values were plotted on a graph to get the defocus curve (range +2D to -3D).

Postoperative refraction

Objective and subjective refraction was performed for all cases. An automated refractometry was performed with the correction factor for the IOL material (Abbe number - 50). Retinoscopy was performed after verifying the IOL position and centration, taking into consideration the patient's keratometry value as the starting point for refraction. Subjective refinement of the sphere was done, starting from the middle point of the defocus curve. Jackson cross-cylinder (±0.5 D) was used to refine the cylinder power and axis.

Contrast sensitivity

Contrast sensitivity was assessed with the Mars Letter Contrast sensitivity chart at 50 cm.[9] The chart consists of 48 letters of equal size with six letters, each arranged in eight rows. The log contrast sensitivity (logCS) score was recorded for the last letter correctly read.

Stereopsis

The near (33 cm) and distance (3 m) stereopsis were assessed binocularly with Randot test (Randot SO-002, Stereo Opticals Co Inc, Chicago, IL) and FD2 stereoacuity test, respectively.[10] The Randot test uses a polaroid vectograph book with different geometric shapes (circle, triangle, square, star), which is held at a distance of 33 cm, and the patient wearing a polarizing glass is asked to identify these shapes. Stereopsis is recorded in seconds of an arc, which varies from 400 to 60 s of arc (arcsec) in this test. The FD2 test is a real depth test and uses a viewing box with four shapes (star, cross, arrow, crescent) that are mounted on horizontal rods that can be moved either away or close to the observer. The patient is asked to identify the object that appears closest to him. The results are recorded in seconds of arc from 200 to 20 at 3 m.

Aberrometry

The ocular aberrations were assessed using iTrace (Tracey Technologies, Houston, Tx).[11] The advantage of this aberrometer is that it provides a separate assessment of corneal, internal and total ocular aberrations as it combines the corneal topography and ray tracing aberrometry principle. The higher-order aberrations (Coma/Trefoil), Modulation transfer function (MTF), and Point Spread Function (PSF) were recorded for evaluation of visual quality.

Pupillometry

The pupil diameter was assessed using NeurOptics PLR-200 Pupillometer (NeurOptics, Inc., Irvine, USA). It is an automated, hand-held, monocular pupillometer that uses infra-red light.[12,13] The pupil diameter was measured at 3-months follow-up under mesopic and photopic conditions.

Patient satisfaction questionnaire

The National Eye Institute Refractive Error Quality of Life instrument-42 (NEI RQL-42) was used to assess the patients' postoperative satisfaction for distance and near vision, visual disturbance, and spectacle independence in performing daily activities.[14] The responses for each question were recorded for analysis.

Data were entered in Microsoft excel sheet, and statistical analysis was performed using SPSS statistical software (version 11.0, SPSS Inc.). Parametric data were expressed as

mean ± SD and were compared with a single sample *t*-test, while non-parametric data were compared with the Mann-Whitney *U* test. The paired *t*-test was used for comparing independent variables. A *P* value of <0.05 was deemed statistically significant.

Results

A total of 55 cases were recruited in the study; however, three cases were lost to follow-up after 1 month and were hence excluded from the study. Fifty-two patients (104 eyes) with bilateral implantation of Supraphob Infocus IOL that completed the final follow-up were included in the final analysis.

Baseline characteristics

The mean age of the patients was 58.4 ± 9.3 years (range, 42 to 78). There were 27 male and 25 female patients. The baseline mean UDVA was 0.84 ± 0.33 logMAR (range, 0.36 to 1.7). The mean IOP was 13.4 ± 2.9 mmHg (range, 8 to 24). The mean axial length and keratometry were 23.3 ± 0.8 mm (range, 21.4 mm to 24.9 mm) and 44.2 ± 1.7 D (range 41.4D and 49.7D), respectively. The mean endothelial cell count was 2580.4 ± 243.4 cells/mm^2.

Postoperative outcomes

Visual acuity

The mean monocular UDVA improved from 0.84 ± 0.33 logMAR at baseline to 0.17 ± 0.09 logMAR at 1 week, 0.12 ± 0.08 logMAR at 1 month and 0.11 ± 0.08 logMAR at 3 months follow-up [Table 1]. At a 3-month follow-up, UDVA of 20/20 was achieved by 62.5% of the eyes (*n* = 65/104), and 20/32 or better was achieved in 96.15% of the eyes (*n* = 100/104). The mean binocular UDVA at the final follow-up was 0.03 ± 0.07 logMAR (range, 0 to 0.18). The mean monocular CDVA was 0.05 ± 0.06 logMAR at 1 week, 0.03 ± 0.04 logMAR at 1 month, and 0.02 ± 0.03 at 3 months follow-up. All cases achieved a binocular CDVA of 20/20. Spectacle independence for distance was achieved in 96.15% of the cases for distance work (*n*-50/52). The mean postoperative MRSE was 0.04 ± 0.37 D at 3-months follow-up. The defocus curve for Supraphob Infocus IOL showed visual acuity of 0.2 logMAR or better between +1D and -2D of defocus, showing a broad range of defocus with good visual acuity [Fig. 2]. Postoperative astigmatism at the final follow-up was 0.38 ± 0.33D.

The mean UIVA was 0.23 ± 0.10 logMAR at 1 week, 0.17 ± 0.05 logMAR at 1 month, and 0.15 ± 0.07 logMAR at 3 months. The UIVA was 20/25 or better in 31.7% of the eyes (*n* = 33/104), 20/32 or better in 75% of the eyes (*n* = 78/104) and 20/40 or better in 94.23% of the eyes (*n* = 98/104). The mean binocular UIVA was 0.14 ± 0.06 logMAR at the final follow-up.

The mean UNVA was 0.41 ± 0.09 logMAR (range, 0.34 to 0.68) at 1 month and 0.41 ± 0.08 logMAR (range, 0.34 to 0.6) at 3 months. UNVA of N-6 or better was achieved in 60.6% (*n* = 63/104) of the eyes and N-8 or better in 93.3% (*n* = 97/104) of the eyes at 3 months follow-up. The mean binocular UNVA at the final follow-up was 0.36 ± 0.05 with N-6 or better visual acuity in 90.4% cases. Spectacle independence was achieved in 92.31% of the cases for near work (*n* = 48/52).

Contrast sensitivity

The mean contrast sensitivity at 1 month and 3 months follow-up was 1.46 ± 0.05 logCS (range, 1.32 to 1.56) and 1.47 ± 0.06 logCS (range, 1.20 to 1.56), respectively. Contrast sensitivity of 1.48 logCS or better was observed in 31.7% cases (*n* = 33/104) and 1.04 logCS or better in 100% cases.

Stereoacuity

The mean distance and near stereo-acuity at 3 months was 90.2 ± 24.8 arcsec (range, 60 to 200 arcsec) and 62.5 ± 19.5 arcsec (range, 30 to 100 arcsec), respectively. Distance stereo-acuity of 60 arcsec or better was observed in 23.1% of the cases (*n* = 12/52), while 86.5% of the cases (*n* = 45/52) had

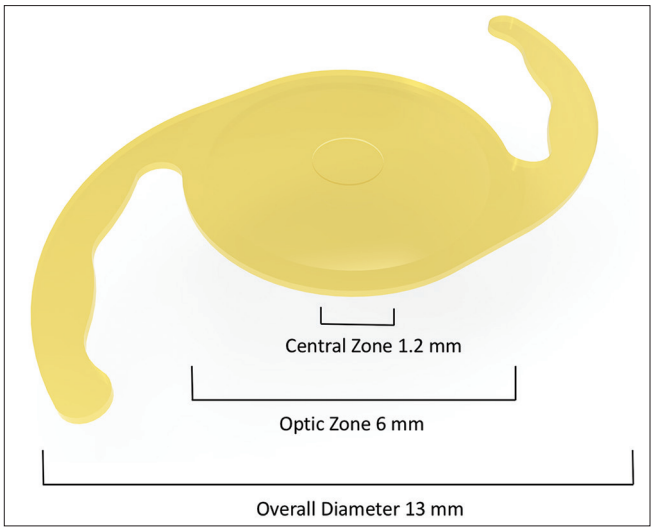

Figure 1: Design of SupraPhob Infocus IOL

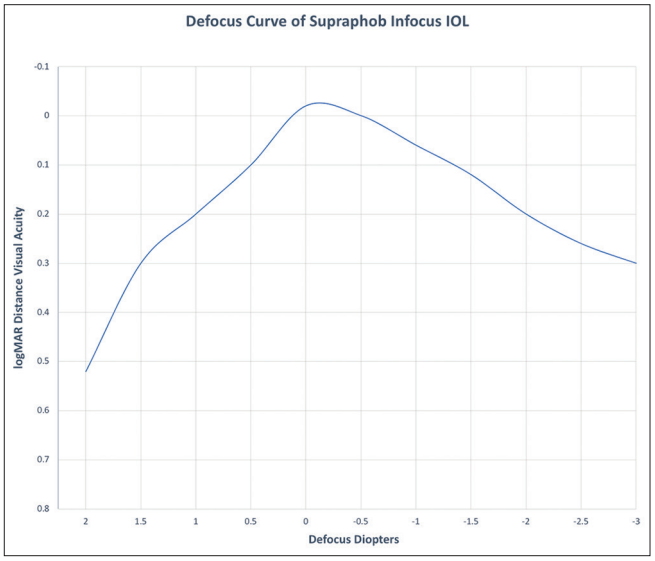

Figure 2: Binocular distance corrected Defocus Curve for Supraphob Infocus IOL

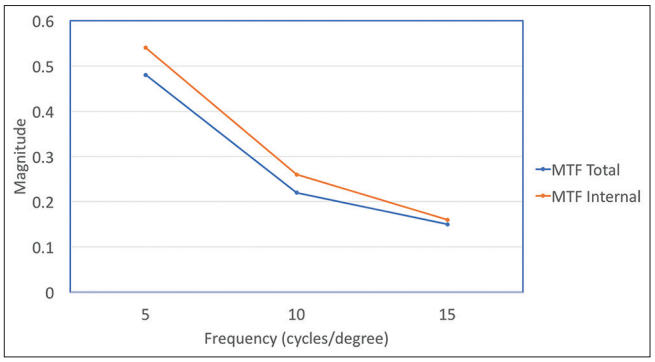

Figure 3: Total and internal modulation transfer function (MTF) following implantation of Supraphob Infocus IOL

a stereoacuity of 100 arcsec or better. Near stereoacuity of 50 arcsec or better was observed in 53.8% (n = 28/52) of the cases, while 100% had a stereo-acuity of 100 arcsec or better.

Aberration

Table 2 shows the detailed results of ocular aberration at the final follow up as assessed on the ray-tracing aberrometer. The parameters evaluated were total HOA, PSF, MTF, coma, trefoil, spherical aberration, and secondary astigmatism. All values were evaluated separately for total and internal aberrations. Besides, the MTF was assessed at 5 cpd, 10 cpd, and 15 cpd to assess the effect of increasing spatial frequency on the modulation of the lens system. The mean total HOA, PSF, and MTF were 0.30 ± 0.13 µm, 0.07 ± 0.08, and 0.26 ± 0.07, respectively. The magnitude of MTF reduced from 0.48 ± 0.16 at 5 cpd to 0.15 ± 0.11 at 15 cpd [Fig. 3].

Endothelial cell loss

The mean endothelial cell density at 1 month and 3 months were 2448.4 ± 255.03 and 2418 ± 243.6 cells/mm^2, respectively. The mean endothelial cell loss was 6.2% at 3 months follow-up.

Pupillometry

The mean postoperative photopic and mesopic pupil diameter was 2.65 ± 0.44 mm (range, 1.6 to 3.7 mm) and as 4.1 ± 0.6 mm (range, 2.3 to 5.4 mm). Pearson's correlation analysis of postoperative mesopic pupil diameter with the UNVA revealed no correlation between the two parameters with a correlation coefficient of 0.014 (P = 0.88). Similarly, no correlation was observed with the UIVA (correlation coefficient = -0.077; P = 0.43). Further, no correlation was observed between the photopic pupil diameter and the UNVA (correlation coefficient = -0.02; P = 0.80) or UIVA (correlation coefficient = -0.16; P = 0.11). Evaluating the total HOA with postoperative photopic and mesopic pupil diameter, no correlation was observed between the two with a correlation coefficient of -0.05 (P = 0.61) and 0.07 (P = 0.43), respectively.

Patient satisfaction questionnaire

The National Eye Institute Refractive Error Quality of Life instrument-42 (NEI RQL-42) was administered in 50 out of the 52 cases. Questions related to near activity revealed no difficulty in reading newspapers in 96% of the patients, while 90% had no difficulty in reading the fine print of the medicine bottles. Questions pertaining to distance vision revealed no difficulty in either walking downstairs, judging distances, or seeing on the sides in any patient. However, 4% of the cases had difficulty in seeing in dark places like a movie theater. Starburst and halos were noticed by 8% of the cases while glare was noted by 10% of the cases. Spectacle independence was observed in all cases for brief reading while 4% of cases sometimes required glasses for reading books/newspapers/magazines. Complete satisfaction with the IOL was observed in 92% of the cases while 8% of cases showed partial satisfaction.

Table 1: Post-Operative Visual Outcome of all cases undergoing bilateral implantation of Supraphob Infocus IOL

	1 month	3 months
Visual Acuity(logMAR)		
UDVA (Uniocular)	0.12±0.08	0.11±0.08
UDVA (Binocular)	-	0.03±0.07
UIVA (Uniocular)	0.17±0.05	0.15±0.07
UIVA (Binocular)	-	0.14±0.06
UNVA (Uniocular)	0.41±0.09	0.41±0.08
UNVA (Binocular)	-	0.36±0.05
Contrast Sensitivity (logCS)	1.46±0.05	1.47±0.06
Distance Stereopsis (3m) seconds of arc	95.38±23.64	90.2±24.78
Near Stereopsis (33cm) seconds of arc	61.15±19.16	62.5±19.49
MRSE (D)	NA	0.04±0.37
Spectacle Independance Distance (%)	NA	96.15%
Spectacle Independance Near (%)	NA	92.31%

Footnotes. UDVA- Uncorrected distance visual acuity; UIVA- Uncorrected intermediate visual acuity; UNVA- Uncorrected near visual acuity; MRSE- Manifest refractive spherical equivalent; D-Diopters; NA- Not assessed

Postoperative complications

None of the patients had any intraoperative or postoperative complications such as posterior capsular opacification, cystoid macular edema, uveitis, or raised IOP. The mean postoperative IOP at 1 week and final follow-up was 13.4 ± 2.9 mmHg and 13.4 ± 2.1 mmHg, respectively. None of the cases had an IOP of >21 mmHg. No patient reported problems of glare or halos.

Discussion

The extended depth of focus IOL is an emerging concept for the correction of presbyopia. It is based on the principle of creating a single elongated focal point to enhance the "range of vision" or "depth of focus" in patients undergoing cataract surgery. The TECNIS Symfony IOL (Johnson and Johnson, Jacksonville, FL) was the first IOL in this category to be USFDA approved in 2016.[7] It has gained immense popularity ever since its introduction. Various studies have been conducted in the past

Table 2: Aberrometry profile of cases undergoing bilateral implantation of Supraphob Infocus IOL at 3-months

Aberrometry Parameters	Mean±SD
HOAs (µm)	
HOAs	
Total	0.30±0.13
Internal	0.27±0.13
Coma	
Total	0.17±0.09
Internal	0.16±0.08
Trefoil	
Total	0.14±0.08
Internal	0.09±0.07
Spherical Aberration	
Total	0.08±0.06
Internal	0.06±0.07
Secondary Astigmatism	
Total	0.05±0.04
Internal	0.05±0.05
PSF	
Total	0.07±0.08
Internal	0.07±0.04
MTF	
Total (5 Cpd)	0.48±0.16
Internal (5 Cpd)	0.54±0.17
Total (10 Cpd)	0.22±0.11
Internal (10 Cpd)	0.26±0.13
Total (15 Cpd)	0.15±0.11
Internal (15 Cpd)	0.16±0.11
Average Total	0.26±0.07
Average Internal	0.29±0.08

HOA-higher order aberrations; PSF- point spread function; MTF- modulation transfer function; cpd- cycles per degree

with this IOL to prove its safety and efficacy in providing good near and intermediate vision.[15–22] However, the high cost of this IOL is often a limiting factor for many patients, especially in developing countries. This study aims to evaluate the efficacy and safety of a new hybrid design EDOF IOL, the Supraphob Infocus IOL (Appasamy associates, Chennai, India) in the visual rehabilitation of patients with senile cataract.

In the current study, most of the patients achieved good visual acuity for distance, intermediate, and near. The mean binocular UDVA achieved with the bilateral implantation of Supraphob Infocus IOL in the current study (0.03 ± 0.07 logMAR) was comparable to the results obtained in various other studies conducted with Technis Symfony IOL.[15–17] [Refer Table 3] The CONCERTO study,[17] largest multicentric study on Technis Symfony IOL, reported a binocular UDVA of 0.03 ± 0.09 logMAR and another study by Pedrotti *et al*.[16] reported similar outcomes (0.04 ± 0.09 logMAR). Spectacle independence for distance was achieved in 96% of the cases in the current study with a negligible residual refractive error (0.04 ± 0.37 D), which was comparable to the CONCERTO study[17] and the study by Titiyal *et al*.[15], which achieved spectacle independence in 92.1% and 96% of the cases, respectively. In the current study, the Sloan chart was used for the assessment of intermediate vision and Snellen's chart for near vision. The variability in charts used by different authors in previously reported literature makes it difficult to make a direct comparison of the results of our study. However, the UIVA achieved by the Supraphob Infocus IOL was comparable to the results of the CONCERTO study (0.14 ± 0.06 vs. 0.13 ± 0.16 logMAR).[17] The UNVA achieved in the current study, although it was less when compared to other studies on Technis Symfony IOL (0.36 ± 0.05 vs. 0.21 ± 0.16 logMAR); however, >90% cases with Supraphob Infocus IOL achieved UNVA of N-6 or better with spectacle independence for near.[17]

Other than visual acuity, visual functions include binocular vision, contrast sensitivity, and visual quality. Patient dissatisfaction following premium IOL implantation despite achieving a good visual acuity is not uncommon and can be attributed to subnormal results in other visual functions.[15] Therefore, in addition to assessing the monocular and binocular visual acuity, we also evaluated the outcomes for stereopsis, contrast sensitivity, and ocular aberrations.

Stereopsis, which is the highest level of binocular visual function, was assessed in the current study. The distance stereopsis was evaluated using the FD2 test, which is a real depth test that simulates real-life scenarios and is more suitable for measuring distance stereopsis when compared to other tests.[10] The distance stereopsis achieved by the Supraphob Infocus IOL was comparable to that achieved by Symfony IOL (90.2 ± 24.8 arcsec on FD2 vs. 103.6 ± 49.1 arcsec on Randot stereo-test).[15] The near stereopsis, although it was less compared to Symfony IOL (62.5 ± 19.5 arcsec vs. 21.1 ± 2.3 arcsec), was still good enough to perform routine near work.[15] This difference observed in near stereopsis could be because a high proportion of patients in Symfony IOL achieved a binocular near vision better than N-6 while the majority of our patients were N-6.[15]

Ocular aberration is an important factor determining the final visual quality. In the current study, ocular aberrations were assessed with the iTrace System. This system has an advantage over other aberrometers to provide separate values for total and internal aberrations by integrating the ray-tracing aberrometry and corneal topography. Comparing the results of postoperative ocular aberrations obtained in the current study with those of Technis Symfony IOL, it was observed that the Supraphob Infocus IOL induces less internal HOAs (0.27 ± 0.13 µm vs. 0.64 ± 0.43 µm).[15] Further, it was important to note that

Table 3: Review of literature of post-operative visual outcome with EDOF IOL

	CONCERTO study	Pedrotti *et al*	Titiyal *et al*	Current study
Type of study	Ambispective, multicentric	Prospective	Prospective	Prospective
Sample size	*299	**55	50	52
IOL design	Technis Symfony	Technis Symfony	Technis Symfony	Supraphob Infocus
Binocular Visual acuity (logMAR)				
UDVA	0.03±0.09	0.04±0.09	0.01±0.04	0.03±0.07
UIVA	0.13±0.16	0.05±0.09	0.09±0.06	0.14±0.06
UNVA	0.21±0.16	0.18±0.10	0.19±0.05	0.36±0.05
Contrast Sensitivity (logCS)	-	CSV1000 1.7 at 6 cycles/degree	-	1.47±0.06
Distance stereopsis (3m)	-	-	103.6±49.1 (Randot)	90.2±24.78 (FD2)
Near Stereopsis (33cm)	-	-	21.1±2.3 (Randot)	62.5±19.49 (Randot)
Aberrations	-			
HOA				
Total		-	0.62±0.41	0.30±0.13
Internal		-	0.64±0.43	0.27±0.13
PSF				
Total		0.18±0.06	0.03±0.02	0.07±0.08
Internal		-	0.03±0.02	0.07±0.04
MTF				
Total		-	0.24±0.08	0.26±0.07
Internal		-	0.24±0.07	0.29±0.08
MRSE (D)	-0.3±1.13	-0.08±0.28	within 0.5D	0.04±0.37
Spectacle Independence Distance (%)	92.1%	77.94±25.72	96%	96.2%
Spectacle Independence Near (%)	72.1%		62%	92.3%

*Total - 411 cases, Emmetropia -299 cases, Intended micromonovision- 112 cases. ** Total cases - 185, Symfony IOL- 55 cases

the values of MTF and PSF obtained in the current study were comparable to that of Technis Symfony IOL (0.29 ± 0.08 vs. 0.24 ± 0.08 and 0.03 ± 0.021).[15] Progressive drop in the MTF with increasing spatial frequency was seen in the current study, and the transition of MTF was comparable to that observed in Symfony IOL in the previous study.[15] The contrast sensitivity, which is another parameter for assessment of visual quality, was assessed by the MARS contrast sensitivity testing system and indirectly by MTF, both of which showed good results.

In the current study, no correlation was observed between the UIVA and UNVA with the pupil diameter. This highlights the pupil independent nature of the Supraphob Infocus IOL in achieving a good intermediate and near vision. Hence, this IOL can be safely implanted in patients with relatively large pupil diameter, unlike a few other multifocal IOLs which are contraindicated in these cases.

Patient satisfaction questionnaire revealed good results for both distance and near vision with spectacle independence in over 95% of the patients for near activity. Dysphotic symptoms like starburst, glare, and halos were noted in <10% of the patients, which is comparable to most of the other multifocal IOLs.

The visual outcomes of Supraphob Infocus IOL were comprehensively evaluated in this study. However, there are a few limitations. The study had a 3 month follow-up period, which although gives a good idea of the short-term postoperative visual outcome; however, an extended follow-up period would have provided additional information on long-term outcomes like rate of PCO.

Conclusion

To conclude, the Supraphob Infocus IOL can be safely implanted in patients undergoing cataract surgery with good visual outcomes. The visual acuity, contrast sensitivity, stereoacuity, and ocular aberrations are comparable to the currently used echellete design EDOF IOL. Besides, no adverse events were noted with the implantation of this IOL. Looking at the safety and efficacy of the Supraphob Infocus IOL, along with its low cost, this IOL can be considered as a potential alternative to the currently available multifocal or EDOF IOLs.

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Conflicts of interest

There are no conflicts of interest.

References

1. Zvorničanin J, Zvorničanin E. Premium intraocular lenses: The past, present, and future. J Curr Ophthalmol 2018;30:287-96.
2. Xiao J, Jiang C, Zhang M. Pseudophakic monovision is an important surgical approach to being spectacle-free. Indian J Ophthalmol 2011;59:481-5.
3. Lichtinger A, Rootman DS. Intraocular lenses for presbyopia correction: Past, present, and future. Curr Opin Ophthalmol 2012;23:40-6.
4. Breyer DRH, Kaymak H, Ax T, Kretz FTA, Auffarth GU, Hagen PR. Multifocal intraocular lenses and extended depth of focus intraocular lenses. Asia Pac J Ophthalmol (Phila) 2017;6:339-49.
5. Rosen E, Alió JL, Dick HB, Dell S, Slade S. Efficacy and safety of multifocal intraocular lenses following cataract and refractive lens exchange: Metaanalysis of peer-reviewed publications. J Cataract Refract Surg 2016;42:310-28.
6. Pepose JS, Burke J, Qazi MA. Benefits and barriers of accommodating intraocular lenses. Curr Opin Ophthalmol 2017;28:3-8.
7. Angela Stark. FDA approves first intraocular lens with extended range of vision for cataract patients [Internet]. FDA2016; Available from: http://www.fda.gov/news-events/press-announcements/fda-approves-first-intraocular-lens-extended-range-vision-cataract-patients. [Last cited on 2019 Aug 14].
8. Buznego C, Trattler WB. Presbyopia-correcting intraocular lenses. Curr Opin Ophthalmol 2009;20:13-8.
9. Dougherty BE, Flom RE, Bullimore MA. An evaluation of the mars letter contrast sensitivity test. Optom Vis Sci 2005;82:970-5.
10. Leske DA, Birch EE, Holmes JM. Real depth versus randot stereotests. Am J Ophthalmol 2006;142:699-701.
11. Xu Z, Hua Y, Qiu W, Li G, Wu Q. Precision and agreement of higher order aberrations measured with ray tracing and Hartmann-Shack aberrometers. BMC Ophthalmol 2018;18:18.
12. Yoo YJ, Yang HK, Hwang J-M. Efficacy of digital pupillometry for diagnosis of Horner syndrome. PLoS One 2017;12:e0178361.
13. Bradley JC, Bentley KC, Mughal AI, Brown SM. Clinical performance of a handheld digital infrared monocular pupillometer for measurement of the dark-adapted pupil diameter. J Cataract Refract Surg 2010;36:277-81.
14. Pakpour AH, Zeidi IM, Saffari M, Labiris G, Fridlund B. Psychometric properties of the national eye institute refractive error correction quality-of-life questionnaire among Iranian patients. Oman J Ophthalmol 2013;6:37-43.
15. Titiyal JS, Kaur M, Bharti N, Singhal D, Saxena R, Sharma N. Optimal near and distance stereoacuity after binocular implantation of extended range of vision intraocular lenses. J Cataract Refract Surg 2019;45:798-802.
16. Pedrotti E, Carones F, Aiello F, Mastropasqua R, Bruni E, Bonacci E, *et al*. Comparative analysis of visual outcomes with 4 intraocular lenses: Monofocal, multifocal, and extended range of vision. J Cataract Refract Surg 2018;44:156-67.
17. Cochener B, Concerto Study Group. Clinical outcomes of a new extended range of vision intraocular lens: International multicenter concerto study. J Cataract Refract Surg 2016;42:1268-75.
18. Cochener B. Influence of the level of monovision on visual outcome with an extended range of vision intraocular lens. Clin Ophthalmol 2018;12:2305-12.
19. Ganesh S, Brar S, Pawar A, Relekar KJ. Visual and refractive outcomes following bilateral implantation of extended range of vision intraocular lens with micromonovision. J Ophthalmol 2018;2018:7321794.
20. Hogarty DT, Russell DJ, Ward BM, Dewhurst N, Burt P. Comparing visual acuity, range of vision and spectacle independence in the extended range of vision and monofocal intraocular lens. Clin Experiment Ophthalmol 2018;46:854-60.
21. Pandit RT. Monocular clinical outcomes and range of near vision following cataract surgery with implantation of an extended depth of focus intraocular lens. J Ophthalmol 2018;2018:8205824.
22. Sachdev GS, Ramamurthy S, Sharma U, Dandapani R. Visual outcomes of patients bilaterally implanted with the extended range of vision intraocular lens: A prospective study. Indian J Ophthalmol 2018;66:407-10.