ORIGINAL ARTICLE

AcuFocus IC-8 intraocular lens for myopic patients with cataract: a retrospective study

Alexander C Poon, MBBS FRACS FRANZCO; Myra B McGuinness, PhD MBiostat
Royal Victorian Eye and Ear Hospital, Melbourne, Australia

Correspondence and reprint requests:
Dr Alexander Poon, 184 High St, Doncaster 3108, Victoria, Australia. Email: alexpoon@ozemail.com.au

Abstract

Purpose: To retrospectively review visual outcomes of patients with myopia who were implanted with the IC-8 intraocular lens in the nondominant eye and a monofocal intraocular lens in the dominant eye at a private ophthalmology clinic in Australia.

Methods: We retrospectively reviewed medical records of consecutive patients aged ≥18 years who had myopia (≥-0.25 diopter) in both eyes and astigmatism (≤-2.50 diopters) in the nondominant eye and underwent bilateral cataract surgery and implantation of the IC-8 intraocular lens in the nondominant eye and a monofocal intraocular lens in the dominant eye between January 2018 and February 2020 at a private ophthalmology clinic in Australia. At 6 months, uncorrected monocular and binocular distance, intermediate, and near visual acuity was assessed. Dysphotopsia symptoms was evaluated with the Quality of Vision questionnaire.

Results: Medical records of 15 men and 10 women aged 28 to 79 (mean, 60.8±11.5) years of Chinese (n=16), Caucasians (n=8), and South Asian (n=1) ethnicity were reviewed. The mean spherical equivalent improved from -2.92 to -1.20 diopters in nondominant eyes and from -2.42 to -0.13 diopters in dominant eyes. Binocularly, 92%, 64%, and 100% of patients achieved uncorrected distance, intermediate, and near visual acuity of logMAR 0 or better, logMAR 0 or better, and logMAR 0.20 (N5) or better, respectively. The mean Quality of Vision questionnaire score was 32.1 for frequency, 25.4 for severity, and 23.9 for bothersomeness of dysphotopsia symptoms. The rate of laser capsulotomy was higher in eyes with the IC-8 intraocular lens than eyes with the monofocal intraocular lens (72% vs 48%, p=0.08).

Conclusions: The IC-8 intraocular lens can extend the depth of focus and is a good option for patients with myopia. It provides good binocular uncorrected distance, intermediate, and near visual acuity when used in conjunction with a monofocal intraocular lens in the dominant eye. Some patients may have dysphotopsia symptoms, but the symptoms are not frequent, severe, or bothering.

Key words: Cataract; Lens implantation, intraocular; Myopia; Visual acuity

Introduction

Modern cataract surgery and intraocular lens (IOL) implantation require consideration and correction of visual outcomes such as spherical errors and astigmatism. In patients with plano postoperative refractive target, over 90% achieved 0.30 logMAR (Snellen chart, 20/40) unaided and over 75% achieved 0.18 logMAR (Snellen chart, 20/30) unaided.[1,2] Optimizing the depth of focus is important so that patients are less reliant on optical correction for far, intermediate, and near distances.

The IC-8 IOL (AcuFocus, Irvine [CA], USA) is an aspheric hydrophobic acrylic monofocal IOL (6 mm in diameter) with an embedded opaque mini-ring (**Figure 1**). The central black opaque ring (3.23 mm in outer diameter) comprises polyvinylidene difluoride and carbon nano-particles. The small aperture in the center (1.36 mm in diameter) extends the depth of focus. Extending the depth of focus was first

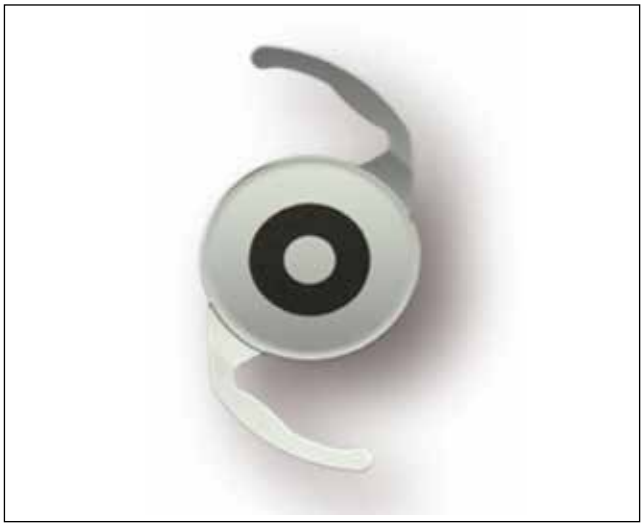

Figure 1. IC-8 intraocular lens with an opaque ring.

used in presbyopia correction using the Kamra corneal inlay. In 32 patients with emmetropia implanted with the Kamra corneal inlay, 74% achieved uncorrected near visual acuity (UNVA) of J3 and 87% achieved uncorrected intermediate visual acuity (UIVA) of 20/32 acuity at 5 years, but the uncorrected distance visual acuity (UDVA) decreased from a mean of -0.20 logMAR (Snellen chart, 20/12.5) to -0.10 logMAR (Snellen chart, 20/16).[3]

In 105 patients implanted contralaterally with a monofocal IOL (targeted for plano) and an IC-8 IOL (targeted for -0.75 diopter [D]), 99%, 95%, and 79% achieved 0.20 logMAR for binocular UDVA, UIVA, and UNVA, respectively.[4] In 109 patients implanted with the IC-8 IOL (targeted for -0.75 D), 90% achieved 0.30 logMAR or better unaided vision for far, intermediate, and near distances.[5] Patients with previous corneal refractive surgery or irregular astigmatism have also been reported to achieve good visual outcomes with the IC-8 IOL.[6-8]

Patients with low to moderate myopia for cataract surgery are often most difficult to please in terms of refractive outcome and unaided near vision, because they have excellent unaided near vision for most of their adult life until they developed cataracts. Monovision enables patients to see both far and near distances. The dominant eye is usually targeted for plano correction for far distance vision, whereas the nondominant eye is targeted for -0.50 D to -2.00 D to allow for intermediate and near vision. However, some patients cannot tolerate the loss of stereopsis owing to a lack of binocularity at any focal point as well as the distance blur on the nondominant eye. Using the IC-8 IOL in the nondominant near-targeted eye may potentially provide distance binocularity and a continuous range of near vision, compared with a typical monofocal IOL. We retrospectively reviewed visual outcomes of patients with myopia who were implanted with the IC-8 IOL in the nondominant eye and a monofocal IOL in the dominant eye at a private ophthalmology clinic in Australia.

Methods

We retrospectively reviewed medical records of consecutive patients aged ≥18 years who had myopia (≥-0.25 D) in both eyes and astigmatism (≤-2.50 D) in the nondominant eye and underwent bilateral cataract surgery and implantation of the IC-8 IOL in the nondominant eye and a monofocal IOL in the dominant eye between January 2018 and February 2020 at a private ophthalmology clinic in Australia. Patients with previous cataract surgery and implantation of monofocal IOL targeted for plano in the dominant eye were also included if the nondominant was myopic and had astigmatism ≤-2.50 D. Patients with visually significant ophthalmic pathology in either eye other than cataract were excluded.

The dominant eye is the eye the patients choose to look through a small aperture at a distance target. With contact lenses, patients were tested for tolerance to anisometropia of -1.50 D or more to determine their suitability for monovision. Surgical alternatives such as multifocal and extended depth of focus IOLs and monovision with single focus IOLs were offered.

All operations were performed under local anesthesia by a single surgeon. The nondominant eyes were targeted for a refractive outcome of -1.00 D to -1.25 D, which is more myopic than that in other studies,[4,5] for better unaided near vision. The dominant eyes were targeted for plano to -0.25 D. The IOL Master Series 700 and the Barrett Universal II formula were used to calculate the IOL power required. Toric IOLs were selected for patients with astigmatism of ≥0.50 D in the dominant eye. The toric power and axis were determined by keratometry and OCULUS Pentacam (OCULUS Optikgeräte, Wetzlar, Germany). The nondominant eyes were implanted with IC-8 IOLs, whereas the dominant eyes were implanted with aspheric monofocal or monofocal toric IOLs. Self-sealing wounds (without sutures) were 3 mm in width for IC-8 and Abbott Medical Optics ZA9003 IOLs and 2.4 mm for other IOLs. The surgical wounds were made in the plus axis of the astigmatism. Phacoemulsification was performed with the Alcon Centurion Vision System. The toric IOLs were aligned with the Alcon Verion Image guided system. The IOLs were implanted into the capsular bag. Postoperatively, topical chloramphenicol and prednisolone acetate 1% eyedrops were provided for 4 to 8 weeks to prevent inflammation and infection.

After 3 months, neodymium-yttrium-aluminum garnet laser capsulotomy was performed for posterior capsular opacification in patients with visual disturbances or decreased visual acuity secondary to posterior capsular opacification.

At 6 months, uncorrected distance, intermediate (60 cm), and near (40 cm) visual acuities (UDVA, UIVA, and UNVA, respectively) were measured on a Snellen-like chart at 6 m (for UDVA) or a Jaeger chart (for UIVA and UNVA). The smallest J number read was converted to logMAR for analysis.

At 6 to 9 months, the self-administered 30-item Quality of Vision questionnaire[9] was used to assess presence of visual symptoms related to dysphotopsias. Patients were asked to score 10 dysphotopsia symptoms (glare, haloes, starbursts, hazy vision, blurred vision, distortion, double or multiple images, fluctuating vision, focusing difficulties, and difficulty judging distances or depth) in terms of frequency (never, occasionally, quite often, or very often), severity (not at all, mild, moderate, or severe), and bothersomeness (not at all, a little, quite, or very). Scores are converted to range from 0 to 100; higher scores indicate worse quality of vision. In addition, patients were asked to rate their dependency on reading glasses (none, a little, moderate, or a great deal) and their satisfaction with vision in bright and dim light (very satisfied, satisfied, neutral, dissatisfied, or very dissatisfied).

Defocus curves were generated by plotting logMAR visual acuity against diopter of defocus based on refractive error. Visual acuities between eyes with IC-8 IOLs and eyes with monofocal IOLs were compared.

Results

Medical records of 15 men and 10 women aged 28 to 79 (mean, 60.8±11.5) years of Chinese (n=16), Caucasians (n=8), and South Asian (n=1) ethnicity were reviewed. Preoperative spherical equivalents for the nondominant and dominant eyes of the patients are shown in **Table 1**. Four of them had previous cataract surgery for the dominant eye with a monofocal IOL for plano implanted. In the dominant eyes, IOLs used included Rayner aspheric nontoric (n=12), Millennium Biomedical PreciSal toric (n=7) and PreciSal nontoric (n=4), Abbott Medical Optics ZA9003 (n=1), and Bausch and Lomb Akreos AO (n=1). Neodymium-yttrium-aluminum garnet laser capsulotomy for posterior capsular opacity was performed for 18 (72%) eyes with IC-8 IOLs and 12 (48%) eyes with monofocus IOLs (p=0.08).

Table 1. Preoperative spherical equivalent of the nondominant and dominant eyes of patients

Preoperative spherical equivalent, diopters	Nondominant eye	Dominant eye
	No. of patients	
0 to <-1	4	7
-1 to <-2	6	4
-2 to <-3	2	5
-3 to <-4	7	3
-4 to <-5	2	4
-5 to <-6	2	0
>-6	2	2

At 6 months, the mean spherical equivalent improved from -2.92±1.88 D to -1.20±0.47 (range, -0.25 to -2.125) D in nondominant eyes and from -2.42±1.82 D to -0.13±0.22 (range +0.25 to -0.50) D in dominant eyes, whereas the mean astigmatism improved from -0.86±0.67 (range, 0.00 to -2.50) D to -0.35±0.41 (range, 0.00 to -1.50) D in nondominant eyes (p=0.001) and from -0.76±0.53 (range, 0 to -1.75) D to -0.19±0.30 (range, 0.00 to -0.75) D in dominant eyes. UDVA tended to be better in eyes with monofocal IOLs (p<0.001), whereas UIVA and UNVA tended to be better with IC-8 IOLs (both p<0.001) [**Table 2**].

Defocus curves of a representative patient is shown in **Figure 2**. At the 0.20 logMAR (N5) threshold, the eye with the IC-8 IOL had a range of 3.50 D, compared with a range of 1.50 D in the eye with the monofocal IOL. With refraction of -1.50 D in the eye with the IC-8 IOL, the patient could read at 30 cm at an acuity of 0.20 logMAR.

20 (80%) patients reported never or occasionally experiencing dysphotopsia symptoms; 20 (80%) patients reported not at all or mild severity of symptoms; and 21 (84%) patients reported not at all or little bothersomeness of symptoms (**Table 3**). The mean score was 32.1 for frequency, 25.4 for severity, and 23.9 for bothersomeness. No patient had adverse effect or complication. For dependency on reading glasses, 40% had none, 36% a little, 12% moderate, and 12% a great deal. For satisfaction with vision in bright and dim light, respectively, 4% and 24% were dissatisfied, 12% and 20% neutral, and 84% and 56% satisfied or very satisfied. No patients were very dissatisfied.

Discussion

Patients with myopia are often dissatisfied with reduced unaided near vision after cataract surgery targeting for plano. This may be improved by the use of trifocal IOLs, extended depth of focus IOLs, or monofocal IOLs targeting distance vision for the dominant eye and intermediate/near vision for the nondominant eye (ie, monovision). The optimal anisometropia is approximately 1.50 D, and the refractive target for the nondominant eye is -1.50 D.[10,11] However, monovision has several disadvantages: (1) blur in the nondominant eye for distance and the dominant eye for near, (2) reduced stereopsis, (3) myopia of -1.5 D is often inadequate for clear unaided vision closer than 40 cm, and (4) nocturnal dysphotopsia. In the present study, 92% and 100% of patients achieved binocular UDVA of 20/20 and binocular UNVA of N5 (0.2 logMAR), which are better than the 68% and 56%, respectively, reported in a study of pseudophakic monovision.[11]

Table 2. Uncorrected distance, intermediate (60 cm), and near (40 cm) visual acuity of the nondominant, dominant, and both eyes at 6 months

LogMAR	Nondominant eye (with IC-8 intraocular lens)	Dominant eye (with monofocal intraocular lens)	Binocular
	% of patients		
Uncorrected distance visual acuity			
>0.18 to ≤0.30	24	4	0
>0.10 to ≤0.18	44	8	8
>0.00 to ≤0.10	12	8	0
≤0.00	20	80	92
Uncorrected intermediate visual acuity			
>0.30	0	56	0
>0.18 to ≤0.30	0	12	8
>0.10 to ≤0.18	4	12	4
>0.00 to ≤0.10	24	20	24
≤0.00	72	0	64
Uncorrected near visual acuity			
>0.50	0	76	0
>0.40 to ≤0.50	0	16	0
>0.30 to ≤0.40	0	8	0
>0.20 to ≤0.30	0	0	0
≤0.20	100	0	100

The IC-8 IOL can enhance monovision by increasing the depth of focus in the nondominant eye. This decreases the sensation of blur and improves stereopsis.

In the present study, the refractive target was -1.00 D to -1.25 D (compared with -0.75 D in two previous studies[4,5]) in nondominant eyes with IC-8 IOLs, because patients were myopic and accustomed to good unaided near vision. In the present study, 100% of patients achieved binocular UDVA of 0.2 logMAR, compared with the 99%[4] and 98%[5], whereas 92% of patients achieved binocular UIVA of 0.2 logMAR, compared with 95%[4] and 83%[5] in two previous studies, and 100% of patients achieved binocular UNVA of 0.2 logMAR (N5), compared with 79%[4] and 76.2%[5] in two previous studies. In the present study, postoperatively, 40% of patients did not wear glasses at all and 36% of patients wore glasses for a small amount of time when ambient light was poor, compared with 54% of patients who were 'glasses independent'.[5] The difference may be due to the inclusion of both myopic and hypermetropic patients in the previous study.[5]

The defocus curves of a representative patient support the improved near vision with a greater myopic refractive target. The eye with the monofocal IOL had a range of 1.50 D at 0.2 logMAR (N5) acuity, whereas the eye with the IC-8 IOL had a range of 3.5 D at 0.2 logMAR acuity. With the IC-8 IOL, a refraction of -0.75 D provides 0.2 logMAR acuity at 40 cm, whereas a refraction of -1.25 D provides 0.2 logMAR acuity at 33 cm. A patient tolerant of 1.5 D of anisometropia can accept -1.25–D target with the IC-8 IOL in the nondominant eye, which provides up to 7 cm of increased close range compared with the -0.75–D target.

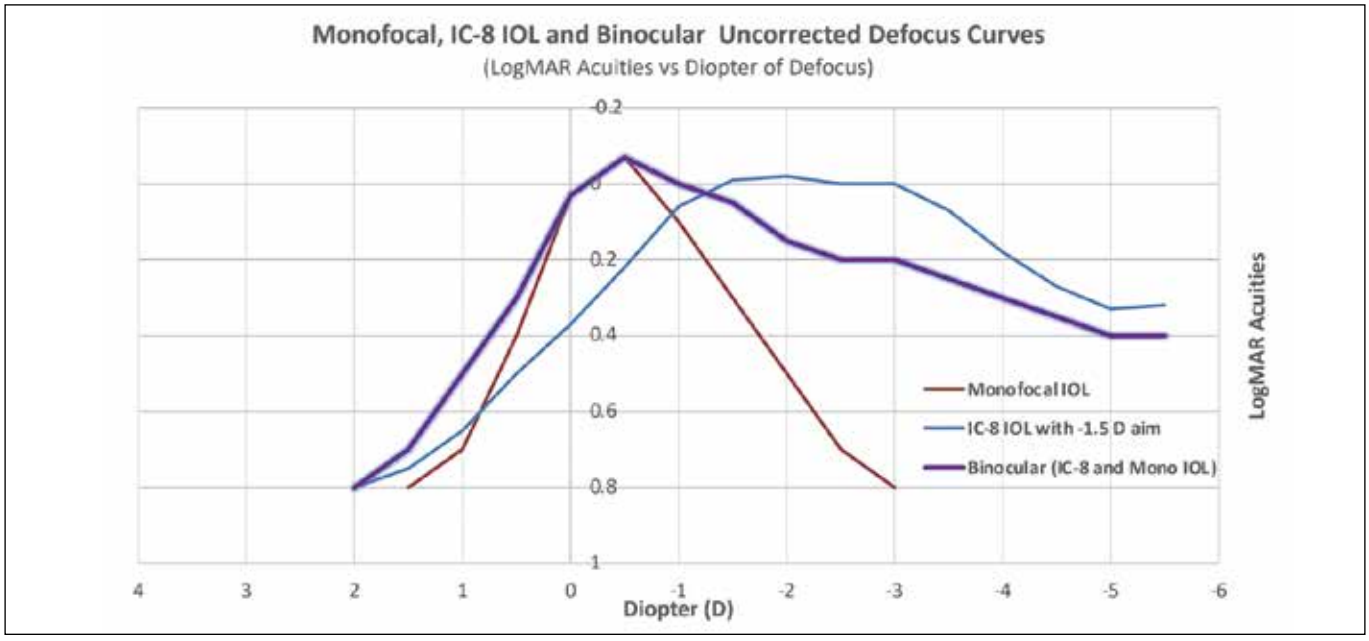

Figure 2. Defocus curves in a representative patient: at the 0.20 logMAR (N5) threshold, the eye with the IC-8 intraocular lens (IOL) has a range of 3.50 diopters, whereas the eye with the monofocal intraocular lens has a range of 1.50 diopters. Binocularly, 0.20 logMAR acuity is maintained across 3.50 diopters from +0.50 diopter to -3.00 diopters.

Table 3. Frequency, severity, and bothersomeness of symptoms based on the Quality of Vision questionnaire

Symptom	None / not at all	Occasionally / mild	Quite often / moderate	Very often / severe
	% of patients			
Glare				
Frequency	36	56	8	0
Severity	40	44	16	0
Bothersomeness	44	48	8	0
Haloes				
Frequency	68	20	8	4
Severity	72	20	8	0
Bothersomeness	72	28	0	0
Starbursts				
Frequency	56	32	12	0
Severity	56	32	12	0
Bothersomeness	64	28	8	0
Hazy vision				
Frequency	68	28	4	0
Severity	76	20	4	0
Bothersomeness	76	20	4	0
Blurred vision				
Frequency	64	32	4	0
Severity	68	28	4	0
Bothersomeness	68	28	0	4
Distortion				
Frequency	100	0	0	0
Severity	100	0	0	0
Bothersomeness	100	0	0	0
Double/multiple images				
Frequency	84	16	0	0
Severity	84	16	0	0
Bothersomeness	96	4	0	0
Fluctuating vision				
Frequency	56	36	8	0
Severity	60	36	4	0
Bothersomeness	76	16	8	0
Focusing difficulties				
Frequency	36	60	4	0
Severity	44	52	4	0
Bothersomeness	52	44	4	0
Difficulty judging distances or depth				
Frequency	68	28	4	0
Severity	72	28	0	0
Bothersomeness	80	20	0	0

Compared with unilateral implantation, bilateral implantation of the IC-8 IOL was reported to achieve better intermediate and near vision but lower patient satisfaction and more dysphotopsias.[12] However, in another study, no significant difference was reported in patient satisfaction between bilateral and unilateral implantation of IC-8 IOL.[13] Disadvantages of bilateral implantation of the IC-8 IOL are poorer binocular vision in dim light and increased nocturnal dysphotopsias, as 24% of our patients were dissatisfied with vision in dim light (compared to 4% in bright light).

The Quality of Vision questionnaire has been used to examine the effects of various IOLs on visual performance.[14-16] The AT LISA 809M was reported to have Rasch-adjusted mean scores of 27, 21, and 16 for frequency, severity, and bothersomeness of dysphotopsia symptoms, respectively, whereas the respective scores for the AcrySof ReSTOR SN6AD1 were 28, 22, and 19.[14] In the present study, the respective scores were higher at 32, 25, and 24. The higher scores are likely due to differences in study populations, as the present study included patients with myopia only and the others not.

The rate of posterior capsulotomy was higher in eyes with the IC-8 IOL than in eyes with the monofocal IOL at 6 months (72% vs 48%, p=0.08), and was higher than the 31.1% for hydrophilic IOLs and 7.1% for hydrophobic IOLs in one study.[17] As the small aperture lens directs light through the small central opening, the quality and clarity of the central capsule behind the aperture becomes more significant. In eyes with the IC-8 IOL, slight opacities and folds in the capsule behind the aperture may affect vision more quickly and necessitate earlier laser capsulotomy. The IC-8 IOL is made from hydrophobic acrylic material with <4% water content, and the posterior surface has a 360-degree square edge. Both features should reduce posterior capsular opacification.

Contraindications of the IC-8 IOL are those with active retinal disease, uncontrolled glaucoma, microphthalmia, chronic uveitis, corneal dystrophy, corneal endothelial dysfunction, and those aged <18 years. Those with mesopic size of >5.6 mm should not use the IC-8 IOL, as light may enter the eye outside of the opaque ring and cause dysphotopsias.[4,12]

Limitations to the present study are the small sample size, the lack of controls, and the retrospective nature. Generalization of our findings to wider populations may not be feasible. Larger prospective randomized controlled studies are warranted to compare postoperative unaided visual acuity and quality of vision in different patients including those with myopia, hypermetropia, and emmetropia. Comparison should be made between different levels of monovision with the IC-8 IOL and with bilateral multifocal IOLs.

Conclusion

The IC-8 IOL is a good option for patients with myopia who can tolerate monovision. It enhances monovision by

extending the depth of focus at near range and binocularity at distance when lighting is adequate. Patients who plan to have the IC-8 IOL implanted in the nondominant eye should be counseled about vision in dim light and the presence of dysphotopsias.

Contributors

All authors designed the study, acquired the data, analyzed the data, drafted the manuscript, and critically revised the manuscript for important intellectual content. All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

Conflicts of interest

All authors have disclosed no conflicts of interest.

Funding/support

This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data availability

All data generated or analyzed during the present study are available from the corresponding author on reasonable request.

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