

Comparison on Visual Function after Implantation of an Apodized Diffractive Aspheric Multifocal or Monofocal Intraocular Lens

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Abstract

Purpose: To evaluate visual outcomes after implantation of an aspheric multifocal/ intraocular lens (MIOL) or an aspheric monofocal intraocular lens (IOL).

Methods: This was a prospective nonrandomized study. During 3-months of post-operative follow-up, the following outcomes for SN6AD1 MIOL (multifocal group) and SN60WF IOL (monofocal group) were compared: uncorrected (UDVA) and corrected (CDVA) distance visual acuity, uncorrected (UNVA) and distance-corrected (DCNVA) near visual acuity, Chinese character near visual acuity, uncorrected intermediate visual acuity (UIVA) under high (100% contrast) and low contrast (10% contrast), UIVA for different IOL powers, and a quality-of-life questionnaire.

Results: UNVA, DCNVA, and UIVA under high contrast in the multifocal group were significantly better than those in the

monofocal group ($P < 0.05$). UDVA, CDVA and UIVA under low contrast did not differ between groups at 63 cm and 100 cm ($P > 0.05$). In most cases, Chinese character near visual acuity was significantly better in the multifocal group ($P < 0.05$). UNVA and UIVA at 63 cm improved over time during 3 months post-operatively. Better UIVA was found in emmetropic and mild myopic eyes as compared to hyperopic ones. The patients in the multifocal group had a higher degree of satisfaction and performed better on near and intermediate tasks, although with greater complaints of visual disturbance.

Conclusion: The SN6AD1 MIOL provides significantly better UNVA, DCNVA and UIVA under high contrast conditions, and better Chinese character near visual acuity. Patients receiving the SN6AD1 MIOL reported a better quality of vision in spite of more serious visual disturbances. Better UIVA was observed in emmetropic and mildly myopic eyes. (*Eye Science* 2012; 27:5–12)

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Introduction

Monofocal intraocular lens (IOL) is the widespread standard of care in cataract surgery¹. However, most patients with traditional monofocal IOL required reading glasses for the near and intermediate distance tasks. Multifocal intraocular lens (MIOL) is considered as an alternative to restore the visual function to be almost free from glasses. Many clinical studies on diffractive MIOLs²⁻⁴, refractive MIOLs⁵⁻⁷, or hybrid MIOLs⁸⁻¹¹ in enhancing quality of vision showed promising outcomes, although with reduced contrast sensitivity^{10,12-16}. The evaluation of a new apodized

diffractive MIOL, AcrySof ReSTOR SN6AD1 MIOL, displayed good visual performances at different distances^{13-14, 17-23}. However, to the present authors' knowledge, no study has detected the acuity of SN6AD1 MIOL under low contrast, which is equally important for daily activities since most everyday objects have less than black-on-white contrast. The high-contrast letter chart acuity used in previous studies reflected only one aspect of visual performance.

The purpose of the current study was to further assess near-, intermediate- and distant-visual acuities under high and low contrast, Chinese character near visual acuity, patients' satisfaction, and visual disturbances after implantation of SN6AD1 MIOL and SN60WF IOL following cataract surgery.

Patients and methods

The prospective study was approved by the ethics committee of Zhongshan Ophthalmic Center affiliated to Sun Yat-sen University. Informed consent was obtained from all patients after the nature and possible consequences of the study were explained. The tenets of the Declaration of Helsinki were followed. Fifty-nine consecutive patients (72 eyes) who underwent sequential cataract extraction and IOL implantation from January, 2010 to September, 2010 were included in this study. All patients were divided into the SN6AD1 group and the SN60WF group according to the types of IOL implanted. Finally, 40 patients (46 eyes) scheduled for SN6AD1 IOL implantation and 19 patients (26 eyes) scheduled for SN60WF IOL implantation were enrolled.

Inclusion criteria: aged between 50 and 78 years; corneal preoperative astigmatism < 1.0 D; and accessible to postoperative examinations. **Exclusion criteria:** other diseases except cataract (severe systemic diseases, amblyopia, corneal diseases, uveitis, retinopathy, or glaucoma); history of ocular surgery; or astigmatism greater than 1.0 D. Intraoperative exclusion criteria included significant vitreous loss leading to inability of in-the-bag IOL implantation and anterior chamber hyphema.

The target refraction ranged from -0.25 D to +0.25 D in the multifocal group and 0 to -0.25 D in the monofocal group. The SRK-T or Haigis formula

was used to calculate IOL power according to the axis length.

Surgical technique

All surgeries were performed by only one experienced surgeon (D.Y) using phacoemulsification with the Infiniti Vision System (Alcon, Inc., USA). After topical anesthesia with 0.05% Alcaine and a temporal 3.0 mm-corneal incision, a central continuous curvilinear capsulorhexis approximately 5.5 mm in diameter was created. Phacoemulsification with torsional ultrasound was performed by irrigation-aspiration of the cortex, and followed by IOL implantation in the capsular bag using a Monarch II injector (Alcon, Inc., USA). Postoperative clinical examinations were arranged at one week, one month and three months postoperatively. The position of IOL was detected by slit-lamp microscopy imaging system with maximum pupil dilation. Anterior segment optical coherence tomography will be conducted, if necessary.

Main outcome measures

All patients were examined one week, and 1 and 3 months postoperatively. UDVA and CDVA, UNVA and DCNVA, UIVA, and Chinese character near visual acuity were measured under bright conditions (100 cd/m²). A 100% contrast early treatment diabetic retinopathy study chart (Precision Vision, USA) was taken to measure UDVA and CDVA at 4m, and UNVA and DCNVA at 35 cm. UIVA was measured under high contrast (100% contrast) and low contrast (10% contrast) at 40 cm, 63cm, and 100 cm using Colenbrander Mixed Contrast Card Set (Precision Vision, USA). A cord on each card ensured that the viewing distance was maintained accurately. Chinese character near visual acuity was measured at 40 cm under high contrast (100% contrast) and low contrast (10% contrast) using the Chinese Reading Chart (Wenzhou Medical College, China), which was in accordance with the Radner Reading Chart.

A questionnaire regarding patients' satisfaction and visual phenomena¹³ was completed three months postoperatively. Patients' satisfaction was based on questions about distance, intermediate, near, and night vision. Patients rated satisfaction with their vision on a scale from 1 to 10 (1=incapacitating; 10=excellent). Patients also rated quality of vision and the incidence of visual phenomena (e.g., glare, ha-

los) on the following scale: 0=none; 1=minimal; 2, 3, and 4=moderate; 5=severe.

Statistical analysis

Statistical analysis was performed using SPSS advanced statistical 13.0 software (SPSS Inc., Chicago, IL). Visual acuity was recorded using the logarithm of the minimum angle of resolution (logMAR) for statistical analysis. All data were expressed as means ±SD. Shapiro-Wilk test was used to check normality. Group comparisons were analyzed by *t*-test, Mann-Whitney U test, or ANOVA. Differences were considered statistically significant when the *P* < 0.05.

Results

Fifty-nine patients underwent all scheduled examinations. The patients’ demographic information was presented in Table 1. There were no statistically significant differences in any index between the two groups. After cataract extraction and in-the-bag IOL implantation, the pupils of all patients were round and showed good responsiveness to light. There was no case of iris trauma. All IOLs were well centered.

The mean UDVA, CDVA, UIVA, UNVA, DCNVA, as well as Chinese character near visual acuity measured at three month postoperatively were

Table 1 Patients’ characteristics preoperatively

Characteristics	Multifocal Group	Monofocal Group	Mean±SD
Number of eyes	46	26	–
Mean age (y)	65.2±8.6	61.1±8.5	0.113
Sex (male/female)	17/23	11/8	–
Mean IOL power (D)	20.8±2.9	20.8±2.2	0.963
Mean axial length (mm)	22.8±0.9	22.8±1.9	0.760
Mean cylinder (D) preoperatively	0.56±0.17	0.56±0.16	0.612
Range of UDVA preoperatively(Log MAR)	1.398–0.222	2.0–0.301	0.158

UDVA=uncorrected distance visual acuity; IOL=intraocular lens

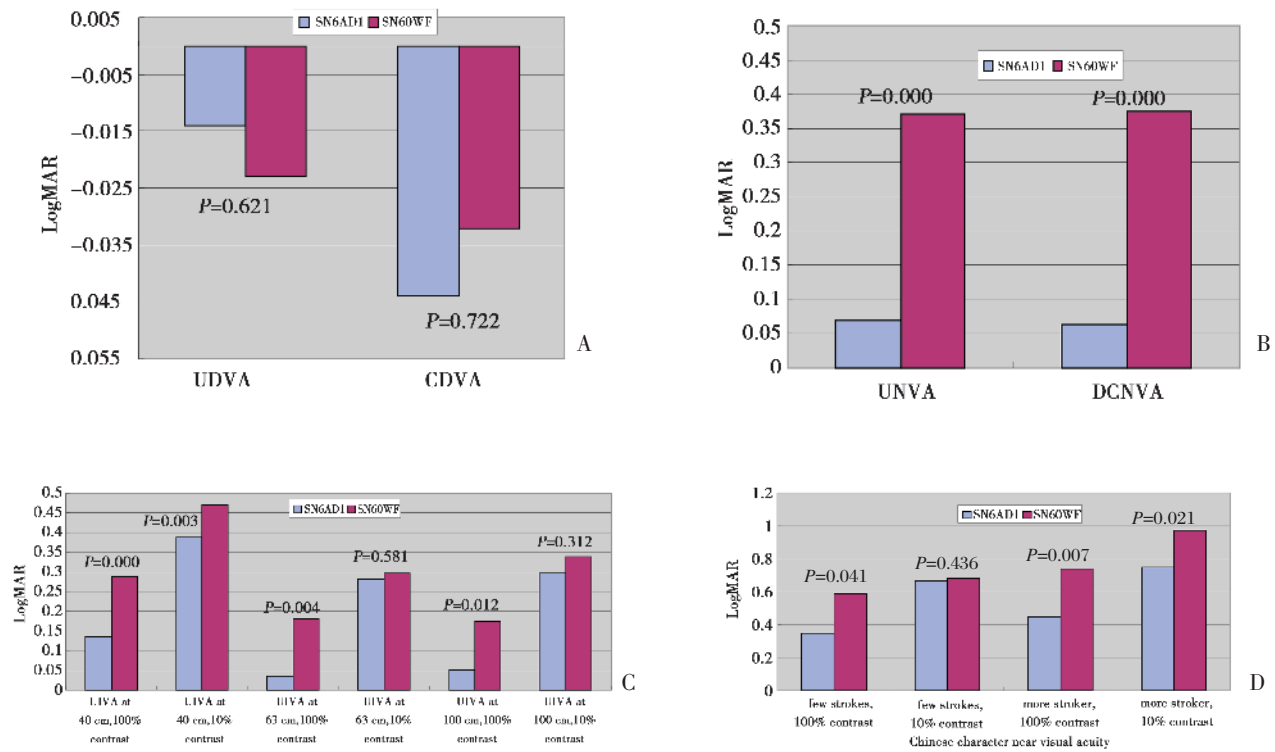


Figure 1 Near, intermediate, and distance visual acuity at the three-month visit (UDVA= uncorrected distance visual acuity; CDVA=corrected distance visual acuity; UNVA= uncorrected near visual acuity; DCNVA= distance-corrected near visual acuity; UIVA =uncorrected intermediate visual acuity)

shown in Figure 1. All patients in both groups achieved an UDVA and CDVA of 20/40 or better. In the multifocal group, 87% and 91% of eyes achieved UDVA and CDVA of 20/25 or better, respectively; In the monofocal group, 85% and 88% achieved those visual acuities. There was no statistical significance in UDVA and CDVA between the two groups ($P>0.05$) (Figure 1A). All patients' UNVA and DCNVA achieved 20/40 or better in the multifocal group, while 46% and 42%, respectively, of eyes in monofocal group presented those visual acuities. In the multifocal group, 85% and 91% eyes' UNVA and DCNVA, respectively, were $\geq 20/25$, while 8% and 8%, respectively of eyes in the monofocal group achieved those visual acuities. Significantly improved UNVA and DCNVA were seen in the multifocal group ($P=0.000$; $P=0.000$) (Figure 1B). The UIVA under high contrast at the three tested distances was significantly enhanced in the multifocal group ($P<0.05$). The UIVA under low contrast was worse than that under high contrast in both groups (Figure 1C). The uncorrected Chinese character near visual acuity in the multifocal group was significantly better than that in the monofocal group ($P<0.05$) except that with fewer strokes in Chinese characters under the low contrast ($P=0.436$) (Figure 1D).

As shown in Figure 2, an improvement in UNVA, UIVA, and UDVA over time, especially significant in UNVA and UIVA at 63 cm, was found in the multifocal group.

Table 2 showed UIVA as a function of different IOL degrees in the multifocal group. Better UIVA was observed in the emmetropia group (18~24D IOL) and the mild myopia group (<18D IOL) than that in the hyperopia group (>24D IOL).

The quality-of-life questionnaire showed a higher overall vision satisfaction in the multifocal group (Table 3). Both groups were comparable in satisfaction regarding distance and night activities without glasses. However, in terms of near and intermediate activities such as reading, cooking, using a computer, shaving, or putting on make-up, the patients in the multifocal group performed better than those in the monofocal group. Although severe glare 0.30 ± 0.52 was reported in the multifocal group compared

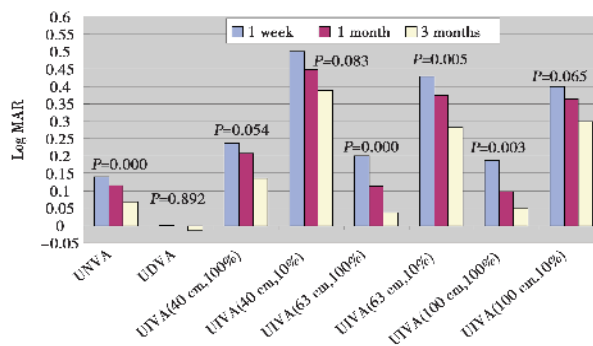


Figure 2 Near, intermediate, and distance visual acuity measured at one-week, one-month, and three-months postoperatively in the multifocal group.

with 0.05 ± 0.23 in the monofocal group ($P=0.048$), it had no worse impact on patients. The visual disturbance gradually diminished or disappeared approximately six months postoperatively.

Discussion

It was generally believed that bilateral implantation of monofocal IOL can fully improve the distance visual acuity. However, patients with these IOL reported more limitations in visual function and were more likely to depend on spectacles for near and intermediate visual acuity than those with MIOL implantation²⁴⁻³⁰. The undesirable UIVA of AcrySof ReSTOR SA60D3 MIOL has been reported^{10,31}, whereas SN6AD1 MIOL gained an improvement in SA60D3 in terms of the aspheric optic surface and lower add power to provide an extended range of vision.

The present study demonstrated that exciting visual acuity from far to near, relatively satisfactory Chinese character near visual acuity, better UIVA as a function of different IOL degrees, and better outcomes of the quality-of-life questionnaire were achieved in SN6AD1 group compared to the SN60WF group.

It has been shown in previous studies^{1-3,8-9,16-19,32} that near visual acuity is better with refractive and diffractive MIOLs than with monofocal IOLs, and that distance visual acuity is comparable. In the present study, approximately 85% of patients in each group had a UDVA $\geq 20/25$, whereas the SN6AD1 IOL gave better performance for near visual acuity. All patients in the multifocal group achieved a UN-

Table 2 UIVA as a function of IOL degree in the multifocal group

IOL degree	Eyes	Mean±SD (log MAR)					
		40 cm, 100%	40 cm, 10%	63 cm, 100%	63 cm, 10%	100 cm, 100%	100 cm, 10%
<18D	11	0.133±0.684	0.308±0.574	-0.045±0.626	0.183±0.700	-0.025±0.522	0.210±0.728
18~24D	26	0.073±0.624	0.355±0.728	0.022±0.438	0.284±0.648	0.008±0.434	0.269±0.620
>24D	9	0.400±0.858	0.655±1.041	0.221±0.416	0.476±0.715	0.374±0.853	0.577±0.988
<i>P</i> -value*		0.063	0.892	0.048	0.053	0.456	0.612
<i>P</i> -value♀		0.000	0.003	0.009	0.005	0.000	0.000
<i>P</i> -value§		0.000	0.000	0.024	0.037	0.000	0.000

UIVA=uncorrected intermediate visual acuity; IOL=intraocular lens

* <18 D group versus 18~24 D group.

♀ <18 D group versus >24 D group.

§18~24 D group versus >24 D group.

Table 3 Results of patient satisfaction and visual phenomena questionnaire administered 3 months postoperatively

Questions	Mean score * ±SD		<i>P</i> value
	Group 1	Group 2	
How satisfied are you with your vision?	7.45±1.26	4.79±0.71	0.000
How much difficulty do you have with...			
blurred far vision?	0.00±0.00	0.00±0.00	1.000
blurred near vision?	0.10±0.31	4.00±1.45	0.000
glare?	0.30±0.52	0.05±0.23	0.048
night vision?	0.23±0.58	0.26±0.56	0.619
halos?	0.15±0.43	0.16±0.37	0.764
watching TV?	0.00±0.00	0.00±0.00	1.000
reading and near work/activities?	0.05±0.22	2.05±1.51	0.000
seeing clearly when you wake up?	0.00±0.00	0.47±0.77	0.000
performing job/hobbies?	0.05±0.22	0.74±1.10	0.001
cooking?	0.08±0.27	1.21±1.18	0.000
reading the time on an alarm clock?	0.05±0.22	2.16±1.42	0.000
driving at night?	0.08±0.27	0.11±0.32	0.699
using a computer?	0.18±0.50	1.89±1.85	0.000
using a cell phone?	0.03±0.16	2.58±1.95	0.000
shaving or putting on make-up?	0.05±0.22	1.37±1.30	0.000
shopping?	0.00±0.00	0.00±0.00	1.000

* Scale for satisfaction with vision ranged from 1 to 10 (1=incapacitating; 10=excellent). Scale for all other questions was 0=none; 1=minimal; 2, 3, and 4=moderate; 5=severe.

Group 1= SN6AD1 MIOL group; Group 2= SN60WF IOL group.

VA \geq 20/40, with 85% \geq 20/25. DCNVA results were also desirable, with all cases achieving \geq 20/25. For patients with SN60WF IOL implantation, 46% and 8% of cases' UNVA were \geq 20/40 and \geq 20/25, respectively, and 42% and 8% of cases had DCNVA \geq 20/40 and \geq 20/25, respectively. The present results agreed with preliminary literatures on the UDVA but were somewhat different in the near visual acuity. Thomas Kohnen³³ reported a better result for the UNVA \geq 20/25 because he ex-

amined the visual acuity with the near vision chart at the patient-preferred distance. However, the testing distance for near visual acuity in the present study was 35 cm instead of 40 cm, the near point of SN6AD1 IOL. Jose' F. Alfonso¹³ assessed 20 patients (40 eyes) with the SN6AD1 model and found 100% of patients' UNVA achieved \geq 20/25, which could be explained by different near vision chart and measuring distance.

The reason for the equivalence of distance visual acuity between groups and the better near visual acuity in SN6AD1 group was likely to be the apodized diffractive multifocal design of the optic, including a low add power (+3D). The gradual decrease in step heights from the center of the optic to the periphery of the diffractive region affects the light distribution to the near- and far-focus. The pupil is relatively small when the viewer focuses on a near object. Compared to the SN60WF IOL, the diffractive region of the SN6AD1 IOL plays an important role in increasing the proportion of light directed to the near focal points in such a case. On the contrary, the pupil is relatively large when the viewer focuses on a far object. The large pupil tends to expose the refractive region of the SN6AD1 IOL and weakens the function of the diffractive region. The amount of light directed to the near focal point will decrease, and the amount directed to the far focal point will increase. Both IOLs present no significant difference in distance visual acuity. Moreover, DCNVA eliminates the effect of refractive error; whether the performance of SN6AD1 IOL in near visual acuity is better remains to be elucidated.

In recent years, the performance of demanding intermediate distance tasks has become increasingly important. However, the concept of intermediate visual acuity has not yet been defined in previous literature. In the present authors' opinion, it is possibly reasonable to define the intermediate visual acuity as the visual acuity between 40 cm- and 100 cm-distance. To the current authors' knowledge, multiple activities such as cooking and doing computer work are completed within 40~100 cm. Besides, there has been no standard measurement of intermediate visual acuity, which was constantly tested using the high-contrast letter chart in previous studies and merely reflected macula's resolution of small targets under high contrast. However, most everyday objects used in the study had less than black-on-white contrast. Therefore, the assessment of intermediate visual acuity, especially under low contrast, is a necessity.

In this study, intermediate visual acuity was measured using Colenbrander Mixed Contrast Card Set. It provided additional low-contrast targets. Moreover, it provided measurements at various intermediate distances. This was important for the assessment of various presbyopia treatments, including MIOL. In addition, the difference between high-contrast and low-contrast visual acuity is one or two lines, occasionally three, for healthy adults. Larger differences indicate a problem. Differences of five or even 10 lines have been found among low vision patients. Finding a low contrast deficit may explain why some patients who still have normal high contrast vision complained about inadequate visual acuity. In this study, better intermediate visual acuities were found at 40, 63, and 100 cm under high contrast in the SN6AD1 group. The reason why no significant difference in UIVA with low contrast was found between the two groups remains elusive. The results in this study implied that SN6AD1 IOL may be a preferential choice for the patients requiring better intermediate visual acuity. However, SN6AD1 IOL patients should be advised to work under high contrast conditions to maximize the advantages of the SN6AD1 IOL. Additionally, SN6AD1 IOL patients should be informed that they will obtain increasingly improving visual function over time during three months postoperatively, especially UNVA

and UIVA. Moreover, the results demonstrated that the emmetropic and mild myopic patients rather than the hyperopic patients should be strongly advised to implant SN6AD1 IOL for the better UIVA.

Additionally, many patients in this study were unable to read the English texts. Consequently, a Chinese Reading Chart was used to measure the Chinese character near visual acuity, whose printing sizes and contents were suitable for Chinese patients and closely simulated daily settings such as reading books, magazines, and newspapers. This offered a more real-word visual assessment. The results in this study indicated that SN6AD1 IOL was a good choice for patients requiring excellent Chinese character near visual acuity.

Quality-of-life questionnaire is intended to reflect the real-life performance better than the visual measurements. It was found that SN6AD1 IOL patients were more satisfied and more easily performed near and intermediate activities compared with SN60WF IOL patients. Visual disturbances occurring in this study were common in other MIOLs^{5,24,25}. In the present study, mild to moderate glare was more frequently found in the SN6AD1 group between one week and one month postoperatively. However, those experiencing visual disturbance in the SN6AD1 group did not require IOL exchange. The visual disturbances disappeared at approximately six months postoperatively. The unwanted visual symptoms are likely due to the design of SN6AD1 IOL. When a distant object is viewed, a sharp retinal image is provided by some parts of the IOL within the papillary area and a blurred image by the other parts of the IOL, and these images were superimposed on the retina. The decrease in contrast of the in-focus image is produced by the split of total light energy between the far- and near-focus, while the superimposition on the retina of an in-focus image and out-of-focus image can induce visual disturbances. However, these problems can be resolved by the brain's neuroadaptation over a period of approximately three months.

In conclusion, SN6AD1 IOL provided an excellent near and intermediate visual acuity, better questionnaire outcomes, and better UIVA in emmetropic and mild myopia eyes compared to SN60WF IOL. Patients with SN6AD1 IOL implantation were more

satisfied with quality of life, despite a certain level of visual disturbances. Further study should be performed to assess the long-term outcomes of the patients with bilateral SN6AD1 IOL implantation.

References

- 1 Leyland M, Zinicola E. Multifocal versus monofocal intraocular lenses in cataract surgery: a systematic review. *Ophthalmology*, 2003; 110: 1789–1798.
- 2 Alfonso JF, Fernandez-Vega L, Senaris A, et al. Quality of vision with the Acri. Twin asymmetric diffractive bifocal intraocular lens system. *J Cataract Refract Surg*, 2007; 33: 197–202.
- 3 Fernandez-Vega L, Alfonso JF, Baamonde MB, et al. Symmetric bilateral implantation of a distance-dominant diffractive bifocal intraocular lens. *J Cataract Refract Surg*, 2007; 33: 1913–1917.
- 4 Alfonso JF, Fernandez-Vega L, Senaris A, et al. Prospective study of the Acri.LISA bifocal intraocular lens. *J Cataract Refract Surg*, 2007; 33: 1930–1935.
- 5 Javitt JC, Steinert RF. Cataract extraction with multifocal intraocular lens implantation; a multinational clinical trial evaluating clinical, functional, and quality-of-life outcomes. *Ophthalmology*, 2000; 107: 2040–2048.
- 6 Montes-Mico R, Alio JL. Distance and near contrast sensitivity function after multifocal intraocular lens implantation. *J Cataract Refract Surg*, 2003; 29: 703–711.
- 7 Montes-Mico R, Espana E, Bueno I, et al. Visual performance with multifocal intraocular lenses; mesopic contrast sensitivity under distance and near conditions. *Ophthalmology*, 2004; 111: 85–96.
- 8 Kohnen T, Allen D, Boureau C, et al. European multicenter study of the AcrySof ReSTOR apodized diffractive intraocular lens. *Ophthalmology*, 2006; 113: 578–584.
- 9 Souza CE, Muccioli C, Soriano ES, et al. Visual Performance of AcrySof ReSTOR apodized diffractive IOL: a prospective comparative trial. *Am J Ophthalmol*, 2006; 141: 827–832.
- 10 Alfonso JF, Fernandez-Vega L, Baamonde B, et al. Prospective visual evaluation of apodized diffractive intraocular lenses. *J Cataract Refract Surg*, 2007; 33: 1235–1243.
- 11 Fernandez-Vega L, Alfonso JF, Rodriguez PP, et al. Clear lens extraction with multifocal apodized diffractive intraocular lens implantation. *Ophthalmology*, 2007; 114: 1491–1498.
- 12 Zhao Y, Li JH, Zhu J, et al. Evaluation of long-term visual performance following AcrySof ReSTOR lens implantation. *Chinese Medical Journal*, 2009; 122: 2705–2710.
- 13 Alfonso JF, Fernandez-Vega L, Amhaz H, et al. Visual function after implantation of an aspheric bifocal intraocular lens. *J Cataract Refract Surg*, 2009; 35: 885–892.
- 14 Hayashi K, Manabe S, Hayashi H. Visual acuity from far to near and contrast sensitivity in eyes with a diffractive multifocal intraocular lens with a low addition power. *J Cataract Refract Surg*, 2009; 35: 2070–2076.
- 15 Robert JC, Robert HO, Michael ES, et al. Visual outcome comparison of unilateral versus bilateral implantation of apodized diffractive multifocal intraocular lenses after cataract extraction; prospective 6-month study. *J Cataract Refract Surg*, 2009; 35: 1033–1039.
- 16 Zeng MB, Liu YZ, Liu XL, et al. Aberration and contrast sensitivity comparison of aspherical and monofocal and multifocal intraocular lens eyes. *Clin Experiment Ophthalmol*, 2007; 35: 355–360.
- 17 Kohnen T, Nuijts R, Levy P, et al. Visual function after bilateral implantation of apodized diffractive aspheric multifocal intraocular lenses with a +3.0 D addition. *J Cataract Refract Surg*, 2009; 35: 2062–2069.
- 18 Maxwell WA, Cionni RJ, Lehmann RP, et al. Functional outcomes after bilateral implantation of apodized diffractive aspheric acrylic intraocular lenses with a +3.0 or +4.0 diopter addition power Randomized multicenter clinical study. *J Cataract Refract Surg*, 2009; 35: 2054–2061.
- 19 Alfonso JF, Fernandez-Vega L, Puchades C, et al. Intermediate visual function with different multifocal intraocular lens models. *J Cataract Refract Surg*, 2010; 36: 733–739.
- 20 De Vries NE, Webers CAB, Montes-Mico R, et al. Visual outcomes after cataract surgery with implantation of a +3.00 D or +4.00 D aspheric diffractive multifocal intraocular lens; Comparative study. *J Cataract Refract Surg*, 2010; 36: 1316–1322.
- 21 Santhiago MR, Netto MV, Espindola RF, et al. Comparison of reading performance after bilateral implantation of multifocal intraocular lenses with +3.00 or +4.00 diopter addition. *J Cataract Refract Surg*, 2010; 36(11): 1874–1879.
- 22 Hayashi K, Manabe S, Yoshida M, et al. Effect of astigmatism on visual acuity in eyes with a diffractive multifocal intraocular lens. *J Cataract Refract Surg*, 2010; 36(8): 1323–1329.
- 23 Lane SS, Javitt JC, Nethery DA, et al. Improvements in patient-reported outcomes and visual acuity after bilateral implantation of multifocal intraocular lenses with +3.0 diopter addition; Multicenter clinical trial. *J Cataract Refract Surg*, 2010; 36(11): 1887–1896.
- 24 Mester U, Hunold W, Wesendahl T, et al. Functional

- outcomes after implantation of Tecnis ZM900 and Array SA40 multifocal intraocular lenses. *J Cataract Refract Surg*, 2007; 33: 1033–1040.
- 25 Chiam PJT, Chan JH, Haider SI, et al. Functional vision with bilateral rezoom and restor intraocular lenses 6 months after cataract surgery. *J Cataract Refract Surg*, 2007; 33:2057–2061.
- 26 Schmidinger G, Geitzenauer W, Hahsle B, et al. Depth of focus in eyes with diffractive bifocal and refractive multifocal intraocular lenses. *J Cataract Refract Surg*, 2006; 32:1650–1656.
- 27 Blaylock JF, Si Z, Vickers C. Visual and refractive status at different focal distances after implantation of the ReSTOR multifocal intraocular lens. *J Cataract Refract Surg*, 2006; 32:1464–1473.
- 28 Bellucci R. Multifocal intraocular lenses. *Curr Opin Ophthalmol*, 2005; 16: 33–37.
- 29 Avitabile T, Marano F. Multifocal intraocular lenses. *Curr Opin Ophthalmol*, 2001; 12: 12–16.
- 30 Steinert RF. Visual outcomes with multifocal intraocular lenses. *Curr Opin Ophthalmol*, 2000; 11:12–21.
- 31 Chiam PJT, Chan JH, Aggarwal RK, et al. ReSTOR intraocular lens implantation in cataract surgery: Quality of vision. *J Cataract Refract Surg*, 2006; 32:1459–1463.
- 32 Hayashi K, Masumoto M, Hayashi H. All–distance visual acuity in eyes with a nontinted or a yellow–tinted diffractive multifocal intraocular lens. *Jpn J Ophthalmol*, 2009; 53:100–106.
- 33 Kohnen T, Nuijts R, Levy P, et al. Visual function after bilateral implantation of apodized diffractive aspheric multifocal intraocular lenses with a +3.0 D addition. *J Cataract Refract Surg*, 2009; 35:2062–2069.