·Clinical Research·

Clinical evaluation of two multifocal intraocular lens implantation patterns

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Abstract

• AIM: To evaluate the visual outcomes and patient satisfaction of two multifocal intraocular lens implantation patterns, with the decision between the two patterns being guided by the patients' choice of visual zones that best suited their lifestyle, or lifestyle zones.

• METHODS: This is a prospective non-randomized comparative study. The lifestyle zones of 32 consecutive age-related cataract patients (64 eyes) were investigated individually to guide the surgical decision between two multifocal intraocular lens implantation patterns. The first group (MIX) received a combined implantation of a ReZoom NXG1 lens in the dominant eye and a Tecnis ZM900 lens in the other eye. The second group (MATCH) received bilateral ReZoom NXG1 lenses. One year postoperatively, the patients were assessed for binocular uncorrected visual acuity, reading visual acuity, reading speed and depth of focus under different luminance and were surveyed for visual disturbances, satisfaction and complete spectacle independence.

• RESULTS: According to the determination of lifestyle zones, 18 and 14 patients were included in the MIX and MATCH groups, respectively. One year postoperatively, each of the patients exhibited positive visual outcomes and lifestyle satisfaction, although there were still some differences between the two groups. Generally, patients in the MATCH group had better distance visual acuity than those in the MIX group. In contrast, patients in the MIX group had better near visual acuity, better reading acuity and better reading speed than those in the MATCH group. Between the two groups, there was no clear difference in intermediate visual acuity, and the depths of focus between the two groups were approximately equal. The results of the mean NEI-RQL-42 questionnaire score, overall satisfaction, and complete spectacle independence did not differ between the two groups.

• CONCLUSION: Different multifocal intraocular lenses implantation patterns can have differing advantages and disadvantages; however, the best results with respect to visual outcome and patient satisfaction can be achieved by taking individual lifestyle zones into account.

• KEYWORDS: intraocular lens;visual outcomes; patient satisfaction

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INTRODUCTION

Today, cataract patients have an array of choices with respect to their surgery due to the introduction of multifocal, accommodating and aspheric intraocular lenses. Among these lens types, multifocal intraocular lenses (MIOLs) are designed to simultaneously allow for distance and near vision. These lenses make use of maturing technologies, and cataract patients are increasingly aware of the availability of these lenses [1]. Clinically, both refractive and diffractive multifocal optics in IOLs have been found to be effective. Refractive MIOLs are characterized by several (usually 5) refractive zones on the anterior surface; however, diffractive MIOLs are based on the Huygens-Fresnel principle [2]. Many new and popular MIOLs have been developed using a combination of these two basic principles. Most randomized trials report improved functional distance and near visual acuity with both types of MIOLs when compared with monofocal IOLs, but reduced image contrast and undesired visual phenomena often decrease patient satisfaction and even lead to patient disputes due to high expectations prior to the surgery[3]. However, the incidence of dissatisfaction related to both types of MIOLs vary with

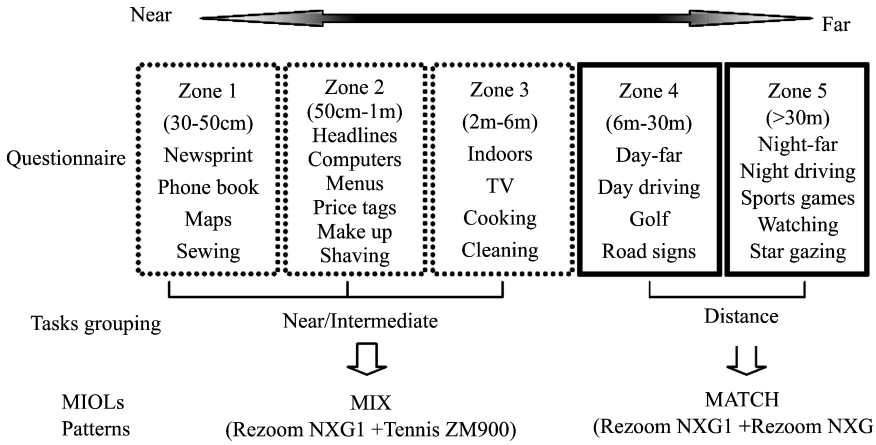

Figure 1 Lifestyle zones determination and groups of MIOL implantation patterns: This model was designed by William Maloney, MD and was modified here for the purpose of our study.

patient selection [4]. Because even the most advanced MIOLs differ from our natural crystalline lens, it is unsurprising that none of the currently available MIOLs meet every patient's needs and desires. Therefore, physicians should choose the MIOL that best suits individual patients' desired outcomes, thereby increasing patients' visual outcomes and satisfaction[5]. How does one take into account patient's desired outcomes to maximize patient satisfaction? It is critical that cataract surgeons appropriately select patients to receive these new types of artificial lenses and educate patients regarding realistic outcomes[6]. To develop an efficacious surgery plan, it is imported to identify a satisfactory method to evaluate the preoperative lifestyle zones of every patient. William Maloney was the first to propose dividing vision into five lifestyle zones. Steven J. Dell developed a now widely used patient questionnaire that aids ophthalmologists in assessing patients' visual needs and lifestyle demands [7]. In this study, we revise the questionnaire, making it more suitable for Chinese individuals, and demonstrate a clinical procedure for choosing a suitable MIOL implantation pattern that is guided by individual lifestyle zones. The objective visual outcomes and subjective patient experiences (including satisfaction and spectacle independence) of the two MIOL implantation patterns were evaluated one year postoperatively.

MATERIALS AND METHODS

This one-year prospective comparative case series study enrolled 32 consecutive patients (64 eyes) with bilateral cataracts who were able to afford MIOLs and met the inclusion criteria. Patients were enrolled between January 2008 and January 2009 at the Department of Cataract of Zhongshan Ophthalmic Centre, Guangzhou, China. The study protocol was approved by the ethics committee of Sun Yat-Sen University. The study's enrollment and informed consent procedures were conducted in accordance with the tenets of the Declaration of Helsinki.

Materials

Inclusion criteria The following inclusion criteria were used for patient enrollment: bilateral senile cataract, a significant decrease in vision (i.e., Snellen visual acuity <20/30) in at least 1 eye, corneal astigmatism<1.5 diopter (D), a willingness to accept undesired visual phenomena (increased glare and halos) and prolonged visual neuroadaptation, availability for postoperative examinations and an ability to understand and sign the informed consent form.

Exclusion criteria The exclusion criteria included pre-cataract myopia or hyperopia >3D; a history of amblyopia; fundus abnormalities that could cause significant visual impairment; previous intraocular surgical procedures; and ocular comorbidities, such as prior trauma, glaucoma, diabetic retinopathy, pseudoexfoliation syndrome, chronic uveitis, corneal opacities, senile miosis or hyporeactive pupil, or alpha-antagonist (tamsulosin) treatment, which may induce floppy iris syndrome. Intraoperative exclusion criteria included iris pupillary trauma, vitreous loss, and inability to place the IOL in the capsular bag.

Lifestyle zones determination After patients were selected for this study, they were asked to complete the "Cataract and Refractive Lens Exchange Questionnaire" developed by Steven J. Dell[7]. The content of this questionnaire divides the patients' preoperative lifestyle into five vision zones. To make the questionnaire more suitable for Chinese individuals, the questions were revised, and the five vision zones were broken into intermediate/near and distance tasks (Figure 1).

The patients were asked to choose the three visual zones that were most important to him or her from the five zones defined by the questionnaire. The patients decided upon these zones based on which activities they would most like to perform without wearing glasses. The patients were then

divided into an intermediate/near tasks group (i.e., patients who chose at least two of Zones 1, 2 and 3) and a distance tasks group (i.e., patients who chose Zone 4 and 5)[8]. This further division helps to establish the visual tasks and activities for which the patient would most like to be free of glasses. This type of preoperative determination is required to take into account the individual patients' postoperative visual outcome that is appropriate to their lifestyle.

MIOL implantation patterns The intermediate/near tasks group was referred to as the MIX group, and the distance tasks group was referred to as the MATCH group. The MIOL implantation pattern chosen for the MIX group was a ReZoom NXG1 IOL (Abbott Medical Optics) in the dominant eye and a Tecnis ZM900 IOL (Abbott Medical Optics) in the other eye [9]. The MATCH group received bilateral implantation of ReZoom NXG1 refractive MIOLs (Abbott Medical Optics) [8]. All of the implanted MIOL powers were calculated using the SRK-T formula, and the target refraction range was 0 to + 0.25D.

Methods

Surgical procedure Sutureless phacoemulsification was performed in all cases by a single surgeon (WR.C). Following application of local or topical anesthesia of 0.4% oxybuprocaine, a 3.2mm clear corneal incision was made temporally. Following complete hydrodissection, a continuous curvilinear capsulorhexis 0.5mm smaller than the MIOL was created. The lens was removed, and the posterior lens capsule was polished. The MIOL was implanted using an injector and was subsequently centered within the capsule with the optic edge completely covered by the capsular bag. The surgical wound was closed using stromal hydration. The second eye was operated upon 1 day later using the same procedure and received one of the two MIOL types, depending on the patient's pattern choice. Each of the patients received topical levofloxacin (Cravit, Santen, Japan) for 3 days preoperatively and tobramycin and a dexamethasone ophthalmic suspension (Tobradex, Alcon China) for 4 weeks postoperatively.

Outcome measures The patients were examined preoperatively and at 24 hours, 1 week, and at 1, 3, 6, and 12 months postoperatively. The primary outcomes were far, near, and intermediate visual acuity of the two groups. The secondary efficacy measures were depth of focus, contrast sensitivity, the patients' overall level of satisfaction, and spectacle independence. The ophthalmic examination included manifest refraction, biomicroscopy, and an evaluation of postoperative posterior capsular opacity, an intraocular pressure measurement, and funduscopy. All of the results presented here are from examinations performed 12 months (±30 days) postoperatively.

Distance uncorrected binocular visual acuities (UCVAs) and distance best spectacle corrected visual acuities (BCVAs) were recorded as logMAR (i.e., the logarithm of the minimum angle of resolution) using a standard logarithm chart at a distance of 500cm. The light densities in the low- and bright-light conditions were 6 and 100 candelas [cd]/m^2, respectively (TES-1332A digital luminometer; TES, Taipei, Taiwan).

High- and low-contrast visual acuities were recorded as visual acuity scores (VAS) using Mixed Contrast Cards for Refractive Surgery/Multifocal lenses [10]. Moreover, under photopic lighting (100cd/m^2) and mesopic lighting (6cd/m^2) conditions, intermediate visual acuities were tested at 100cm and 63cm. Near visual acuities were tested at 40cm.

Patients' reading acuities were tested using Chinese Reading Charts (Jia Qu) [11]. In accordance with previous reports[12,13], reading speed was tested using a third grade elementary school text with a 12-point print size and 1.5 line spacing. The patients were asked to read a sentence binocularly as rapidly and accurately as possible while the other sentences were covered with a piece of paper. The number of words read per minute was recorded. Each of the measurements of reading ability without correction was performed at a standard reading distance (25cm) and at an optimal reading distance under both bright light (100cd/m^2) and low light (6cd/m^2) conditions.

Pseudo-accommodative amplitude was generally evaluated as the depth of focus and was measured using a defocusing technique (i.e., a minus-lenses-to-blur method) [14,15]. The subjective trial lens-induced accommodation method was implemented as follows. The subjects were asked whether their vision remained sharp when the fixation target was defocused with negative lenses. When their vision became blurred, the power difference between the lens used and the subjects' initial ametropia was considered to represent the accommodation amplitude. At the same time, logarithmic distance visual acuity was measured monocularly and binocularly using interposing trial lenses ranging from +3.00 D to -5.00 D in -0.5 D steps. The best binocular visual acuity with each spherical addition was recorded.

A "Refractive Error Quality of Life Instrument-42 (NEI-RQL-42)" questionnaire was used to assess patients' difficulties in vision-dependent activities of everyday life. This questionnaire has been found to correlate highly with patient satisfaction following cataract surgery [16-17]. This instrument was translated into Chinese and administered 6 and 12 months postoperatively. The patients were asked to score their satisfaction for every item. A score of 100 indicated perfectly satisfied, a score of 80 indicated very satisfied, a score of 60 indicated a little satisfied, a score of

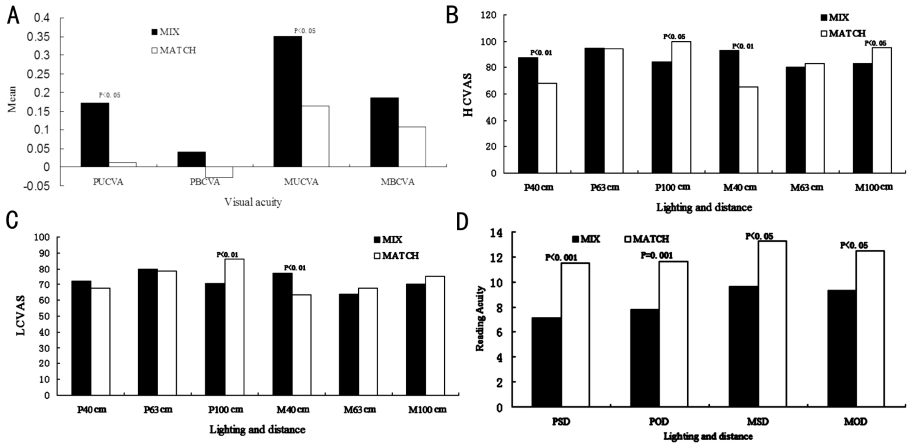

Figure 2 Visual acuity measurements (Log MAR) at a distance of 500cm under photopic and mesopic conditions are shown in Figure 2A; High-contrast visual acuities at near and intermediate distances under photopic and mesopic conditions are shown in Figure 2B; Low-contrast visual acuities at near and intermediate distances under photopic and mesopic conditions are shown in Figure 2C; Reading acuities measured under photopic and mesopic conditions are shown in Figure 2D PUCVA=photopic uncorrected visual acuity; PBCVA=photopic best corrected visual acuity; MUCVA=mesopic uncorrected visual acuity; MBCVA=mesopic best corrected visual acuity; HCVAS=high-contrast visual acuity scores; LCVAS=low-contrast visual acuity scores; P40cm=photopic acuity at 40cm; P63cm= photopic acuity at 63cm; P100 cm=photopic acuity at 100cm; M40 cm=mesopic acuity at 40cm; M63cm=mesopic acuity at 63cm; M100 cm=mesopic acuity at 100cm; PSD=photopic acuity at standard distance; POD=photopic acuity at optimal distance; MSD= mesopic acuity at standard distance; MOD=mesopic acuity at standard distance.

40 indicated a little dissatisfied, a score of 20 indicated very dissatisfied, and a score of 0 indicated very disappointed. The higher the score, the better the quality of vision. The remaining 2 questions related to difficulty with night and daylight vision (i.e., presence or absence of halos and glare). Postoperative spectacle independence was also evaluated. Data regarding all of these parameters, including the NEI-RQL-42 questionnaire score, satisfaction level, halos, glare, and spectacle independence, were collected by two trained ophthalmologists and entered onto computer spreadsheets.

Statistical Analysis The between-group comparison was performed using ANOVAs for numerical variables and the Pearson or Fisher exact Chi-square test for categorical variables. All of the tests were 2-sided, with confidence levels set at 95%. Statistical analyses were performed using SPSS software (version 17.0, Inc. Chicago, Illinois, USA), and P<0.05 was considered significant.

RESULTS

Thirty-two patients (64 eyes) who met the inclusion criteria were enrolled. The individual lifestyle zones of the participants were determined using questionnaires, and the patients were preoperatively divided into two groups according to Figure 1.

According to our defined criteria for MIOL implantation patterns, 18 patients (36 eyes) were placed in the MIX group, and 14 patients (28 eyes) were placed in the MATCH group. There were 11 males and 7 females in the MIX group, which had a mean age of 70.1±7.3 years. There were 6 males and 8 females in the MATCH group, which had a mean age of 70.7±4.8. Based on Chi-square and univariate ANOVA tests, there were no significant differences between the groups in terms of patient genders and ages.

There were no significant differences in age, sex, and preoperative spherical equivalent between the MIX and MATCH groups. Because the preoperative spherical equivalent can be influenced by cataract-induced refractive changes, available data regarding patients' pre-cataract refraction were used to exclude any significant differences in terms of percentage of myopes versus hyperopes between the groups. The preoperative photopic and mesopic pupil diameters and BCVAs were comparable among the groups (data not shown).

No intraoperative complications occurred in any of the included eyes. Following the surgery, the pupils in all eyes were round and showed good responsiveness to light. No clinically significant cystoid macular edema, prolonged intraocular pressure increase, or corneal edema was observed. During the 12-month follow-up, no clinically significant IOL decentration (i.e., >0.5mm) was observed. In all eyes, the posterior capsule maintained adequate transparency for optimal posterior pole biomicroscopy.

Visual Acuity Figure 2A indicates that binocular BCVA measurements were not statistically different under photopic lighting (100cdm^2) and mesopic lighting(6cdm^2) conditions; however, the difference in binocular UCVA measurements was significant (P<0.05) between the MIX and MATCH groups at a distance of 500cm. The distance uncorrected

Table 1 Reading speed measured under photopic and mesopic lighting conditions

Luminance	100cd/m^2		6cd/m^2	
Group	ORD (cm)	RS (words/min)	ORD (cm)	RS (words/min)
MIX(±SD)	37.1(5.4)	195.93(47.17)	33.9(6.3)	176.47(51.9)
MATCH(±SD)	35.6(3.4)	153.42(44.06)	34.4(3.8)	135.92(44.75)
T value		2.395		2.142
P value		0.24		0.039*

ORD=optimal reading distance; RS= reading speed; SD=standard deviation * P<0.05 indicates a statistically difference.

Table 2 Subjective function scores in the two implantation groups at 12 months

	MIX group	MATCH group	P Value
Modified NEI-RQL-42 Mean score (±SD)	99.1 (1.9)	97.6 (5.8)	>0.05
Patients' overall satisfaction Mean* (±SD)	4.8 (0.4)	4.9 (0.4)	>0.05
Halos No. cases (%)	0 (0)	1 (7.1)	>0.05
Glare No. cases (%)	1(5.6)	0 (0)	>0.05
Complete spectacle independence No. (%)	18/18 (100%)	13/14 (91.1%)	>0.05

SD=standard deviation. *Patients' overall satisfaction evaluated using a 5-point scale ranging from 1 (very dissatisfied) to 5 (very satisfied).

visual acuity of the MATCH group was better than that of the MIX group.

Figure 2B illustrates that under photopic (100cd/m^2) and mesopic (6cd/m^2) lighting conditions, the MIX group exhibited statistically better high-contrast visual acuity at a distance of 40cm than did the MATCH group. A statistically better high-contrast visual acuity at a distance of 100 cm was also observed in the MATCH group. However, high-contrast visual acuities at 63cm were not significantly different between the two groups in photopic and mesopic lighting conditions.

Figure 2C indicates that under photopic lighting condition, the MATCH group exhibited a statistically better low-contrast visual acuity at a distance of 100cm than did the MIX group. Under mesopic lighting conditions, the low-contrast visual acuity at a distance of 40cm was statistically better in the MIX group than for the MATCH group. Low-contrast visual acuities at a distance of 63cm were not significantly different between the 2 groups in photopic and mesopic lighting conditions.

Reading Acuity and Reading Speed Figure 2D illustrates reading acuity by group under photopic and mesopic lighting conditions. The reading acuities without correction were significantly better for the MIX group than for the MATCH group at standard (25cm) and optimal reading distances.

Reading speed is another index of near vision acuity. Table 1 lists the reading speeds of the two groups under photopic and mesopic lighting conditions. Under mesopic luminance, the reading speed at the optimal reading distance without correction was significantly better for the MIX group than for the MATCH group. However, under the photopic lighting condition, the difference between two groups was less striking.

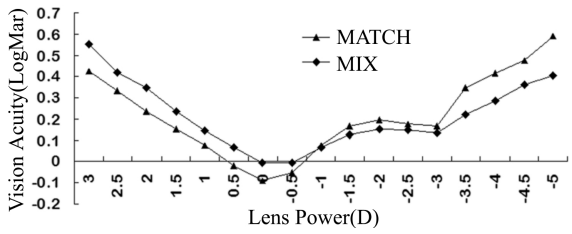

Figure 3 The double valley curves obtained from best binocular visual acuity tests with defocusing (minus-lenses-to-blur technique) in the two implantation groups at 12 months following the operation.

Depth of focus Figure 3 depicts the double valley curves of the best binocular visual acuity with defocusing in the two implantation pattern groups. The groups both exhibited a first valley minimum near the best corrected visual acuity and a second valley minimum at -3.25D, indicating that the near point was 31cm(distance=1/diopter) for both implantation patterns. We observed two intersection points of the two curves, one at -1.5D and one at -3.25D. In the interval between -1.5D and -3.25D, the curve of the MATCH group was above that of the MIX group, indicating that the MIX group has better near vision over the 31-67cm range. At distances greater than 67cm, the curve of the MIX group was above that of the MATCH group, indicating that patients with the MATCH implantation pattern have better visual acuities at distances greater than 67cm. The total binocular amplitude of accommodation was 5.38±0.95D in the MATCH group and 5.5±1.08D in the MIX group. There was no statistically significant difference between the groups.

Patient Satisfaction Table 2 summarizes the 12-month modified NEI-RQL-42 scores, overall satisfaction levels, difficulties with night and daylight vision (i.e., the presence or absence of halos and glare), and the percentage of

spectacle independence. The postoperatively NEI-RQL-42 scores were significantly improved over preoperative scores, without intergroup differences. Furthermore, overall satisfaction, night halos, daylight glare and complete spectacle independence did not significantly differ between the two groups; however, 1 case of night halos occurred in the MATCH group, and 1 case of daylight glare occurred in the MIX group.

DISCUSSION

The expansion of intraocular lens options has created excitement in the field of lens surgery, but with the new paradigm comes new challenges [18]. In the old paradigm, surgeons typically used a standard favorite IOL that they implanted in most patients, and there was little discussion regarding the IOL itself. Today, surgeons can offer a much wider range of choices, and these choices should be tailored to fit the patient's lifestyle needs. It follows that the patient should play an active role in deciding which lens to implant.[1] Currently, clinicians not only need to educate patients regarding cataracts but also must 1) be aware of patients' visual needs and desires and 2) educate patients regarding the available technologies that can meet those needs. Patient-centered care has been described as a type of health care that is responsive to patients' desires, needs and preferences [19,20]. However, very little has been published regarding ophthalmic patient expectations in China [21,22].It is essential that patients have realistic expectations regarding their postoperative vision [23]. These expectations are partly dependent on the preoperative education process but are also related to the individual's personality. Assessing personality type can be one of the most difficult aspects of this process for surgeons, especially if they have not had practice doing so in the past [24]. Therefore, passing a psychological evaluation was one of our inclusion criteria in our study. We asked patients to self-identify where they fall in a range from easygoing to perfectionist, but the surgeon also must make an intuitive assessment during the preoperative exam. The next step in determining whether one of the newer IOLs is appropriate is the medical eye exam. To be eligible for implantation of an advanced aspheric lens or a presbyopic lens, the patient should have a healthy optical system. These IOLs demand minimal refractive error for optimal outcome, including less than 1.5D of astigmatism, so patients with forme fruste keratoconus or other corneal pathology are not ideal candidates.

The concept of dividing vision into five lifestyle zones, first described by William Maloney, MD, has been very helpful for us in guiding lens choice [7]. The activities described in these zones range from near tasks, which would require a near-dominant lens or undercorrection in Zone 1, to distance tasks, which would require pristine distance vision or perfect emmetropia in Zone 5. For patients, real-world examples in these lifestyle zones are much more useful than asking them whether they want 20/20 or J1 vision; we therefore present the above clinical procedure for choosing a suitable MIOL implantation pattern that is guided by individual lifestyle zones. In our study, we used a questionnaire based on one developed by Steven J. Dell, MD [7]. We then translated and modified this questionnaire to make it more suitable for Chinese. The lifestyle zones of the participants were surveyed and assigned to one of two MIOL implantation patterns prior to surgery. The questionnaire helps us to assess and prioritize what is important to the patient. It asks, for example, whether the patient wants to be able to read without glasses and for which types of activities he/she would least mind wearing glasses. During our interaction with the patient, we augment standard history questions with some additional questions regarding the patient's occupation (current or former), e.g., how often he/she uses a computer, reads or does handiwork, or whether he/she participates in sports or needs to be able drive at night. These questions help us understand the range of vision these patients use in their daily lives and, therefore, which lens would be most suitable for them. We explain to patients that every lens has limitations. For example, we cannot offer them Zones 1, 3 and 5, which were requested by one of our included patients. Knowing whether they would prefer to reduce their dependence on glasses for Zones 1 to 3 or Zones 4 to 5 is very helpful in lens selection, even when a presbyopic IOL is not under consideration. According to lifestyle zone determination, 18 patients were included in the MIX group and 14 patients were included in the MATCH group. Our clinical purpose for attempting mixing and matching patterns was to overcome some of the limitations of each MIOL [25]. Our former research in combined implantation of refractive and diffractive multifocal intraocular lenses also demonstrated positive results [9]. In this study, however, our aim was to tailor a recommendation to patients' lifestyles and to give them the information they needed to make the best decision.

One year postoperatively, all patients had good visual outcomes and lifestyle satisfaction, although there were still some differences between the two groups. In general, the MATCH group had better distant visual acuity than the MIX group, but the MIX group had better near visual acuity, better reading acuity and better reading speed than the MATCH group. Under photopic and mesopic lighting conditions, high-contrast near visual acuity at a distance 40 cm was better in the MIX group, while high-contrast near visual acuity at a distance of 100cm was much better in the

MATCH group. Similar results were observed in Ulrich and Salvatore's studies[26]. The diffractive MIOL (Tecnis ZM900 IOL) used in the MIX group has a pattern of rings that, under photopic lighting conditions, produces near and far primary focal points that are independent of pupil aperture; an intermediate focal point is not present. The refractive MIOL implanted in the dominant eye of the MIX group has 5 refractive zones on the anterior surface: a central, circular zone with the power required for distance correction and 4 annular zones, providing an alternating sequence of near and distance power. An aspheric transition between these zones provides for intermediate distance vision. Because of the missing intermediate focal point, the patients in the MIX group exhibited poorer intermediate distance vision results than the MATCH group. In contrast, the reason that the MIX group provided better near vision may be that the primary near focal point design allowed more light energy for near vision tasks.

When we assess near-vision performance, we measure the capability of the patient to recognize a series of letters on a near-vision chart. However, a legitimate question is whether this method is the correct way to evaluate near vision and to measure the success of presbyopic refractive surgery. It is reasonable to conclude that a more functional activity, such as reading, may be a better test of this ability. Reading is an important everyday task, but the lack of a concise definition makes it difficult to apply objective criteria to any measure of reading. Hutz assessed the reading performance of patients implanted with 3 different pseudo-accommodating intraocular lenses (IOLs) by evaluating reading acuity and reading speed tests [13]. In this study, we used a similar method to evaluate the reading ability of Chinese patients following the surgeries. In general, patients in the MIX group had a more satisfactory reading ability. However, no statistically significant difference was observed in reading speed under the photopic lighting condition[9]. The reason for this finding may be that reading involves the activation of complicated mental processes that interpret concepts and meanings that are stimulated by the recognition of printed symbols. Education, culture and habits play an important role in reading processes. This complexity may therefore have masked any effects of the different lens patterns on reading ability. In this study, we found that the added benefits of the two types of implantation patterns were not sufficient and that patients preferred to use reading glasses when longer or smaller words were read.

Depth of focus is a term used to describe a region in which the image created by an optical system exhibits a required sharpness. Depth of field refers to the same concept applied to objects; i.e., objects within the range of a depth of field must be imaged with a sufficient image quality to be recognized [27]. To measure depth of field in a clinical investigation, it is necessary to place visual acuity charts at various distances from the patient whose visual acuity is being tested [28]. Another possibility is to defocus the eyes while the object remains at the same distance. In our study, the total binocular amplitude of accommodation in the MIX and MATCH groups was 5.5D and 5.38D, respectively. It is known that there should be 6-8 diopters of accommodation amplitude to provide individuals with suitable accommodation in daily near distance activities; however, our participants were satisfied with the above artificial accommodation amplitude. The ideal results of the mean modified NEI-RQL-42 questionnaire score, overall satisfaction, night halos, daylight glare and complete spectacle independence did not significantly differ between the two groups; however, 1 case of night halos occurred in the MATCH group, and 1 case of daylight glare occurred in the MIX group. In conclusion, individualized MIOL implantation patterns based on different lifestyle zones can achieve optimal visual outcomes and satisfaction.

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