



Visual Results Following Implantation of a Refractive Multifocal Intraocular Lens in One Eye and a Diffractive in the Contralateral Eye

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Abstract

Objectives: To assess the visual outcomes in patients who underwent cataract surgery with multifocal intraocular lens (IOL) implantation using a “mix and match” approach.

Materials and Methods: Twenty patients (40 eyes) were involved in this prospective, nonrandomized study. Refractive multifocal IOLs (ReZoom NXG1) were implanted in patients’ dominant eyes and diffractive multifocal IOLs (Tecnis ZMA00) were implanted in their non-dominant eyes. Monocular and binocular uncorrected distance, intermediate and near visual acuity (logMAR), and contrast sensitivity levels were measured at 1, 3, and 6 months after cataract surgery. Defocus curves, reading speeds, patient satisfaction, spectacle dependence, and halo and glare symptoms were also evaluated at 6 months after the surgery. Postoperative quality of life was assessed with the Turkish version of National Eye Institute Visual Function Questionnaire-25.

Results: The study group comprised 8 females and 12 males with a mean age of 69.45 ± 10.76 years (range, 31-86 years). The uncorrected distance and intermediate visual acuity levels were significantly better in the ReZoom-implanted eyes at postoperative 6 months ($p=0.026$ and $p=0.037$, respectively). There was no statistically significant difference in uncorrected near visual acuity ($p>0.05$). There was no statistically significant difference in contrast sensitivity, reading speed, halos, or glare between the groups ($p<0.05$). Mild glare/halo was reported by 40% of the subjects. The mean patient satisfaction was 95% and all patients were spectacle independent.

Conclusion: Mixing and matching multifocal IOLs in selected cataract patients provides excellent visual outcome, a high level of patient satisfaction, and spectacle independency.

Keywords: Mix and match, multifocal intraocular lenses, cataract

Introduction

Presbyopia is still one of the most challenging optical problems in cataract and refractive surgery, and spectacle independence is one of the major demands of the patients. Various presbyopic intraocular lenses (IOL) have been implanted to treat presbyopia during cataract surgery.^{1,2,3}

Multifocal IOLs have good clinical results with careful patient selection.^{4,5,6,7} Clinically, there are two types of multifocal

optics in IOLs: diffractive and refractive. Refractive multifocal IOLs provide very good visual results for intermediate and distance vision, but offer limited near vision.^{8,9,10,11,12} Diffractive multifocal IOLs provide very good results at near vision, but may not function effectively at intermediate distances.^{8,9,10,11,12,13,14}

The ReZoom NXG1 multifocal IOL (Abbott Medical Optics, Santa Ana, CA, USA) is a three-piece, refractive, hydrophobic acrylic, aspheric IOL with UV blocking and an OptiEdge design that is claimed to minimize edge glare and

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reduce posterior capsular opacification. The refractive surface has 5 optical zones (zones 1, 3, and 5 are distance-dominant, whereas zones 2 and 4 are near-dominant). An aspheric transition between the zones is designed to provide balanced intermediate vision. It is designed to allow 100% light transmission in order to provide the full range of vision.¹⁵

The Tecnis ZMA00 multifocal IOL (Abbott Medical Optics, Santa Ana, CA, US) is a three-piece foldable, diffractive, aspheric, UV-blocking, hydrophobic acrylic optic with OptiEdge design. The modified, prolate anterior surface is designed to reduce spherical aberrations. The diffractive zones are located on the posterior surface. The diffractive pattern is 32 concentric circles with a +4 diopters (D) near addition that evenly splits the light entering the eye into two focal planes regardless of pupil size: one for distance and one for near.¹⁶

As with all multifocal IOL technologies, each of these unique designs has its limitations. With the aim of increasing patient satisfaction and spectacle independence after cataract surgery, a “mix and match” method involving implantation of a refractive multifocal IOL in one eye and a diffractive multifocal IOL in the contralateral eye, was first described by Gunenc in 2000. Preliminary findings with this approach were published in 2004 and long-term results in 2008.^{17,18} The aim of this method is to extend depth of focus and quality of vision as well as decrease photic symptoms, increase spectacle independence rates, and improve distance, intermediate, and near visual acuity.

In this study, we evaluated visual results and patient satisfaction after using a “mix and match” approach of implanting new-generation refractive multifocal IOLs (ReZoom NXG1) in dominant eyes and diffractive multifocal IOLs (Tecnis ZMA00) in the nondominant eyes.

Materials and Methods

Forty eyes of 20 patients (8 females and 12 males) who were examined at our clinic and had bilateral cataract were prospectively enrolled in this study. Using the “mix and match” approach, all patients received the ReZoom NXG1 refractive multifocal IOL in their dominant eye, followed by implantation of the Tecnis ZMA00 diffractive multifocal IOL in their nondominant eye two weeks later. The dominant eye was determined via a pinhole test. All patients were adequately informed and signed an informed consent form. The study was performed in accordance with the Declaration of Helsinki and was approved by the Dokuz Eylül University local ethics committee.

Bilateral cataract patients who did not want to wear glasses or contact lenses after surgery and had realistic expectations were included the study. The exclusion criteria were previous ocular surgery, ocular disease other than cataract, corneal astigmatism greater than 1.00 D, axial length (AL) less than 21.0 mm or more than 26.0 mm, myopia and hypermetropia greater than 5.00 D, pupil width less than 3 mm under dim light, and intraoperative complications.

Intraocular lens power calculation was made by using each patient’s keratometry, AL, and the A-constant of the IOL using

both A-scan ultrasound (A-scan Nidek 3000, NIDEK Co., Japan) and laser interference biometry (the IOLMaster Version V2.02, Carl Zeiss Meditec AG, Germany). Biometry was done by the same doctor (R.Y.K.). Targeted refraction was emmetropia in all eyes. After considering both measurements and each patient’s AL, keratometric values, and anterior chamber depth, the SRK-T formula was used to determine the power of multifocal IOL to be implanted.

Surgical Technique

All operations were performed by the same surgeon (U.G.). After the application of topical anesthesia (proparacaine hydrochloride 0.5%), 2.8 mm clear corneal incisions were made in the superior or temporal quadrants, at the steep corneal axis. After filling the anterior chamber with viscoelastic substance, a continuous curvilinear capsulorhexis was created with a diameter of approximately 5 mm. After creating two side ports, hydrodissection was performed. The nucleus and epinucleus were aspirated by phacoemulsification, and cortical cleaning was accomplished by bimanual irrigation/aspiration. The capsular bag and anterior chamber were filled with viscoelastic substance. Both IOLs were inserted using the UNFOLDER[®] Emerald XL delivery system (Abbott Medical Optics, Santa Ana, CA, USA). The viscoelastic substance was aspirated by bimanual irrigation/aspiration, and the operation was completed with stromal hydration and intracameral 1% cefuroxime injection. There were no intraoperative or postoperative complications. After surgery, patients received prednisolone acetate 1% and ofloxacin 0.3% eye drops 6 times per day for the first postoperative week. Ofloxacin was stopped at the end of the first week and patients were advised to continue prednisolone acetate 4 times per day for 3 weeks.

Outcome Measurements

Patients were examined for anterior segment findings at 1 and 7 days following surgery. Patients were evaluated at 1, 3, and 6 months postoperatively. At every follow-up visit, spherical equivalent values, keratometry, monocular and binocular uncorrected distance visual acuity (UDVA) at 4 meters using Early Treatment of Diabetic Retinopathy Study (ETDRS) chart, monocular and binocular uncorrected near visual acuity (UNVA) using ETDRS Near LogMAR Chart 2000 (Precision Vision, LaSalle, IL) at 40 cm, and monocular and binocular uncorrected intermediate visual acuity (UIVA) with ETDRS Near LogMAR Chart 2000 at 100 cm were assessed. Results were evaluated using logMAR visual acuities.¹⁹ Monocular and binocular contrast sensitivity under photopic (85 cd/m²) and mesopic (3 cd/m²) conditions was measured using the Functional Acuity Contrast Test Chart of the Optec 6500 vision tester (Stereo Optical, Chicago, Illinois, USA).

At 6 months after surgery, defocus curve and focus depth (NIDEK RT-5100 Foropter, NIDEK CO., LTD.), and monocular and binocular reading speed under the same conditions using Turkish version of MNREAD (Minnesota Low Vision Reading Test) cards²⁰ were measured. Every sentence of MNREAD card consists of 3 lines and 60 characters. Chart 1 and 2 include 19

logarithmic sentences in the logMAR range of -0.5 to 1.3 with 0.1 logarithmic intervals. Patients were asked to read a sentence as fast and accurately as possible while the sentences below were covered with a piece of paper. Patients reading speed was evaluated from the beginning until the critical print size, which was the smallest print size the patient could read at maximum reading speed. Reading time was measured with a stopwatch. Reading time and number of errors were recorded for each sentence. Patients' right eyes were evaluated with chart 1 and left eyes with chart 2. Then binocular reading speed was measured with chart 1. Reading speed was calculated using the following formula: reading speed (words/min)=60 × (10 - number of errors)/time (s).

Quality of life, halo, glare phenomena, spectacle independence, adaptation time to photic phenomena, and eye preference were also evaluated at 6 months after surgery. The Turkish version of the National Eye Institute Visual Functioning Questionnaire-25 (NEI VFQ-25) was used to evaluate the patients' quality of life.²¹ Patients who had halo and glare were asked to grade phenomena on a scale of mild, moderate, or severe. The patients were also asked whether they would suggest the "mix and match" approach to other patients. For all measurements, monocular examinations (first right eyes, then left eyes) were done before binocular examinations.

Statistical Analysis

Data were evaluated using SPSS version 15.0 software. For complementary analysis, mean values, standard deviation, and percentage values were used. Visual acuity values were converted to logMAR equivalents for statistical analysis.¹⁹ Visual functions of the refractive and diffractive groups were compared using the Mann-Whitney U test. Friedman test was applied to compare visual acuities and spherical equivalent values at 1, 3, and 6 months postoperatively. Spearman correlation analysis was used to determine whether there is a correlation between the patient satisfaction and postoperative results at 6 months. A p value less than 0.05 was considered statistically significant.

Results

The study group consisted of 40 eyes of 20 patients, including 8 females (40%) and 12 males (60%). The mean age of the patients was 69.45±10.76 years (range, 31-86 years). The mean preoperative corrected distance visual acuity (CDVA) was 0.33±0.22 logMAR.

Spherical Equivalent Values

At postoperative 6 months, the mean spherical equivalent was -0.04±0.12 D in ReZoom-implanted eyes and -0.11±0.2 D in Tecnis-implanted eyes. There was no statistically significant difference in spherical equivalent values between refractive and diffractive groups at 1, 3, or 6 months postoperatively (p>0.05).

Visual Acuity Outcomes

Visual acuity outcomes were not significantly different at 1, 3, or 6 months postoperatively, therefore only the 6-month results are presented.

Monocular Distance Visual Acuity

All eyes achieved UDVA of 0.2 logMAR or better in the refractive group, compared with 90% of the eyes in the diffractive group. Mean UDVA was 0.00±0.09 logMAR in the refractive group and 0.09±0.13 logMAR in the diffractive group. UDVA was significantly better in the refractive group than the diffractive group (p=0.026) (Table 1).

Monocular Near Visual Acuity

Sixty-five percent of the eyes in the refractive group achieved a UNVA of 0.2 logMAR or better, compared with 80% of the eyes in the diffractive group. Mean UNVA was 0.24±0.14 logMAR in the refractive group and 0.16±0.1 logMAR in the diffractive group. No statistically significant difference was noted between the groups (p>0.05) (Table 2).

At postoperative 6 months, the patients were asked to hold the near chart where they could best read it. Mean patient-preferred reading distance was 32.1±3.0 cm in the diffractive eyes and 35.85±6.05 cm in the refractive eyes. The patients' best binocular reading distance was 33.75±3.55 cm. Patient-preferred reading distance was statistically significant closer in diffractive eyes (p=0.034).

Monocular Intermediate Visual Acuity

All eyes achieved UIVA of 0.2 logMAR or better in the refractive group, compared with 80% of the eyes in the diffractive group. Mean UIVA was 0.14±0.22 logMAR in the refractive group and 0.19±0.13 logMAR in the diffractive

Table 1. Monocular uncorrected distance visual acuity at postoperative 6 months

LogMAR	Refractive eyes n (%)	Diffractive eyes n (%)
-0.2	1 (5)	0
-0.1	5 (25)	0
0	8 (40)	11 (55)
0.1	5 (25)	3 (15)
0.2	1 (5)	4 (20)
0.4	0	2 (10)

*Uncorrected distance visual acuity was significantly better in the refractive group (p=0.026)

Table 2. Monocular uncorrected near visual acuity at postoperative 6 months

LogMAR	Refractive eyes n (%)	Diffractive eyes n (%)
0	1 (5)	3 (15)
0.1	4 (20)	6 (30)
0.2	8 (40)	7 (35)
0.3	3 (15)	4 (20)
0.4	2 (10)	0
0.5	2 (10)	0

*There was no statistically significant difference between groups (p>0.05)

group. The refractive group had significant better intermediate vision ($p=0.037$) (Table 3).

Figure 1 shows monocular and binocular UDVA, UIVA, and UNVA values at 1 month, 3 months, and 6 months postoperatively.

Binocular Visual Acuity

The patients' mean binocular UDVA, UIVA, and UNVA levels at postoperative 1, 3, and 6 months are shown in Table 4. At the 6-month postoperative visit, all patients achieved an UDVA of 0.1 logMAR or better. Fifteen patients (75%) achieved an UNVA of 0.1 logMAR or better and 18 patients (90%) achieved an UIVA of 0.1 logMAR or better.

Figure 1 shows the monocular and binocular UDVA, UIVA, and UNVA at 1, 3, and 6 months postoperatively. Binocular visual acuity results were better than monocular results at all distances throughout the follow-up.

Contrast Sensitivity

Contrast sensitivity levels of the all binocular, refractive, and diffractive groups were within normal limits both under photopic and mesopic conditions throughout follow-up. No statistically

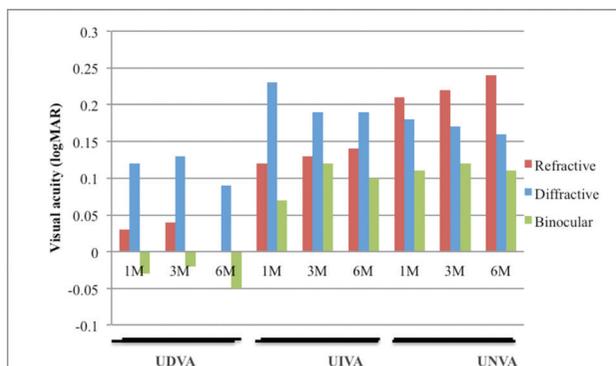


Figure 1. Monocular and binocular uncorrected distance visual acuity, uncorrected intermediate visual acuity and uncorrected near visual acuity at 1 month, 3 months, and 6 months postoperatively

UDVA: Uncorrected distance visual acuity, UIVA: Uncorrected intermediate visual acuity, UNVA: Uncorrected near visual acuity

LogMAR	Refractive eyes n (%)	Diffractive eyes n (%)
-0.1	1 (5)	1 (5)
0	7 (35)	1 (5)
0.1	5 (25)	4 (20)
0.2	7 (35)	10 (50)
0.3	0	2 (10)
0.4	0	1 (5)
0.5	0	1 (5)

*Uncorrected intermediate visual acuity was significantly better in the refractive group ($p=0.037$)

significant difference was noted between the refractive and diffractive groups at any spatial frequencies under photopic or mesopic conditions at 1, 3, or 6 months postoperatively ($p>0.05$). Figures 2 and 3 shows the contrast sensitivity curves of the binocular, refractive, and diffractive eyes in photopic and mesopic conditions at 6 months postoperatively.

Defocus Curve

The diffractive eyes were significantly better than the refractive eyes between +4.00 and +3.00 D ($p<0.05$) and between -3.00 D and -5.00 D ($p<0.05$). The refractive eyes were significantly better than the diffractive eyes at +0.5 D ($p=0.038$). There was

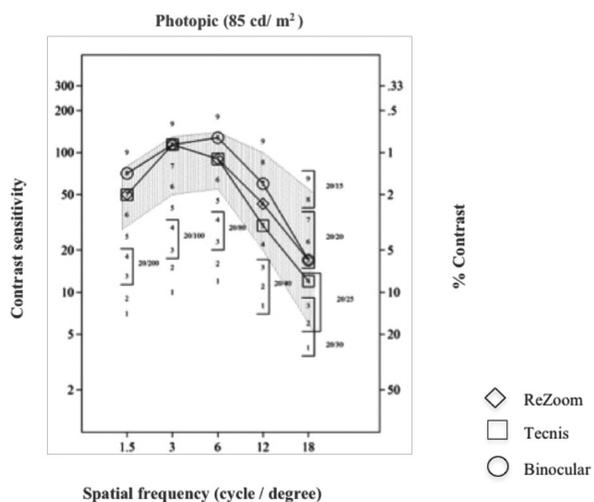


Figure 2. Contrast sensitivity curves of all groups under photopic conditions at postoperative 6 months

	Mean	SD	Median	Minimum	Maximum
1st month					
UDVA	-0.03	±0.10	0.0	0.20	-0.20
UIVA	0.07	±0.08	0.10	0.20	-0.10
UNVA	0.12	±0.09	0.10	0.30	0.0
3th month					
UDVA	-0.02	±0.10	0.0	0.20	-0.20
UIVA	0.12	±0.23	0.10	1.00	-0.10
UNVA	0.12	±0.08	0.10	0.30	0.0
6th month					
UDVA	-0.05	±0.09	-0.10	0.10	-0.20
UIVA	0.09	±0.23	0.05	1.00	-0.10
UNVA	0.11	±0.09	0.10	0.30	0.0

UDVA: Uncorrected distance visual acuity, UIVA: Uncorrected intermediate visual acuity, UNVA: Uncorrected near visual acuity

no statistically significant difference between diffractive and refractive eyes with regards to intermediate distance.

Binocular vision achieved the best results at all distances in the defocus curve. The binocular vision results were significantly better than those of diffractive eyes between +1.50 and -2.00 D ($p < 0.05$) and those of refractive eyes between +4.00 and +1.50 D ($p < 0.05$) and between -2.50 and -5.00 D ($p < 0.05$).

Mean depth of focus of the refractive, diffractive, and binocular group were 5.0 D, 5.5 D, and 6.0 D, respectively. Figure 4 shows the defocus curves of all groups at 6 months postoperatively.

Spectacle Independence

All patients had satisfactory spectacle-free visual function in their daily life during the follow-up period.

Subjective Symptoms and Patient Satisfaction

According to NEI VFQ-25 questionnaire results, patient satisfaction was 90% or above with regards to distance and near activities, social functions, and driving. Ninety-five percent of the patients stated that they would suggest multifocal IOL implantation with the “mix and match” approach to other patients. When asked whether there was any difference between each eye’s visual acuity and visual quality, 5 patients (25%)

preferred the vision in their refractive eye and 2 patients (10%) preferred the vision in their diffractive eye, while 13 patients (65%) reported no difference between the two eyes.

In terms of photic phenomena such as halo and glare, 11 patients (55%) reported mild and 5 patients (25%) reported moderate symptoms at postoperative 3 months. Eight patients (40%) reported mild and 2 patients (10%) reported moderate symptoms at postoperative 6 months. One patient reported symptoms in the diffractive eye only, while the other patients reported equal symptoms in both eyes. Only one patient in the early postoperative period reported watching TV with sunglasses due to severe glare. The severity of the symptom decreased at the end of the second postoperative month. At postoperative 6 months, one patient had complaints of mild glare. However, it did not cause any difficulty in the patient’s daily life. When the patients were asked how long it took to get used to photic phenomena, the average time needed to adapt was 28.4 ± 37.1 days (0-120 days). Ninety-five percent of the patients reported their distance, intermediate, and near visual acuity as “perfect or very good”.

Reading Speed

Patients’ mean reading speed in both refractive and diffractive eyes was the same, at 166 words/min. Binocular mean reading speed was 177 words/min. None of the patients had posterior capsular opacification or IOL dislocation during the follow-up period.

Discussion

Several surgical techniques have been developed for the correction of pseudophakic presbyopia, including monovision,^{21,22} multifocal IOLs,⁶ accommodative IOLs,²³ toric multifocal IOLs,²⁴ and trifocal IOLs.²⁵ The concept of mixing and matching refractive and diffractive multifocal IOLs was first described by Gunenc and Celik.^{17,18} It is known that refractive multifocal IOLs provide good UDVA and UIVA,^{26,27} while diffractive multifocal IOLs provide good UDVA and UNVA.^{27,28,29,30} Mixing and matching different IOLs could allow the surgeon to combine the advantages of both refractive and diffractive lens designs.

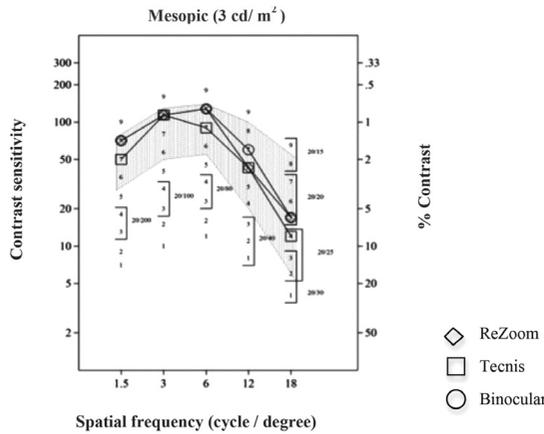


Figure 3. Contrast sensitivity curves of all groups under mesopic conditions at postoperative 6 months

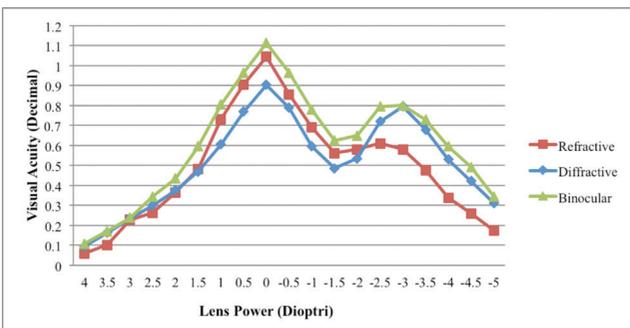


Figure 4. Defocus curves of all groups at postoperative 6 months

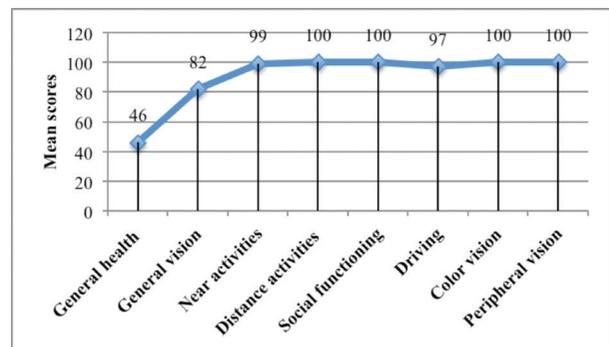


Figure 5. National Eye Institute Visual Functioning Questionnaire-25 questionnaire results

In Gunenc's initial study,¹⁸ 10 patients received the diffractive multifocal IOL (811E CeeOn-diffractive group) in 1 eye, another 10 patients received the refractive multifocal IOL (Array SA40N-refractive group) in 1 eye, and the other 10 patients underwent bilateral implantation with the refractive multifocal IOL in one eye and diffractive multifocal IOL in the other eye ("mix and match" group). The results demonstrated that 100% of the patients in the "mix and match" group, 90% of the patients in the refractive group, and 80% of the patients in the diffractive group had UDVA of 20/25 or better. In addition, 90% of the patients from the "mix and match" group were able to live without spectacles, compared to 60% in the other groups. All patients were satisfied with their visual functions over long-term follow-up.

Currently available second-generation multifocal IOLs have overcome some of the drawbacks of the first-generation models. The results of the "mix and match" approach have been reported in a number of studies. Goes,³¹ Hütz et al.,³² and Lubiński et al.³³ reported the results of 20 patients who received ReZoom in their dominant eye and Tecnis ZM900 in their nondominant eye. Similarly, in the current study 20 patients received ReZoom in their dominant eye, but hydrophobic acrylic Tecnis ZMA00 in their nondominant eye (Table 5). In all four of these studies, patients' binocular UDVA, UIVA, and UNVA were within satisfactory levels and levels of spectacle independence were quite high.

In the current study, UDVA in the ReZoom-implanted eyes was significantly better than in the Tecnis-implanted eyes. At 6 months after implantation, UDVA was 0.1 logMAR or better in the 95% of the ReZoom-implanted eyes versus 70% of the Tecnis ZMA00-implanted eyes. Binocular UDVA was 0.1 logMAR or better in all of the patients (20/20). Hütz et al.³² reported UDVA of 0.1 logMAR or better in the 80% of the ReZoom-implanted eyes but only 20% of the Tecnis ZM900-implanted eyes at postoperative 3 months. Binocular UDVA was 0.1 logMAR or better in 85% of the patients. In both studies, monocular UDVA results in the ReZoom-implanted eyes were significantly better than in the Tecnis-implanted eyes. In this study, 65% of the ReZoom-implanted eyes achieved an UIVA of 0.1 logMAR or better,

compared with 30% of the Tecnis ZMA00-implanted eyes at postoperative 6 months. Monocular UIVA results in the ReZoom-implanted eyes were significantly better than the Tecnis-implanted eyes. Ninety percent of the patients (18/20) achieved a binocular UIVA of 0.1 logMAR or better. Lubiński et al.³³ reported that 90% of their patients achieved a binocular UIVA of 0.0 logMAR at 6 months postoperatively. However, they evaluated UIVA at 60 cm in their study, whereas it was evaluated at 100 cm in our study.

In Hütz et al.³² study, none of the ReZoom-implanted eyes achieved a UNVA of 0.1 logMAR or better, compared with 60% of the Tecnis ZM900-implanted eyes at postoperative 3 months. Sixty percent of the patients achieved a binocular UNVA of 0.1 logMAR or better. In our study, 25% of the ReZoom-implanted eyes achieved an UNVA of 0.1 logMAR or better, compared with 45% of the Tecnis ZMA00-implanted eyes at 6 months postoperatively. Seventy-five percent of the patients achieved a binocular UNVA of 0.1 logMAR or better. In both studies, UNVA results in the Tecnis eyes were better than in the ReZoom-implanted eyes; however, the difference was statistically significant only in Hütz et al.³² study.

When the "mix and match" approach is used, it is usually recommended to implant the refractive multifocal IOL in the dominant eye.³⁴ However, Yoon et al.³⁵ suggest implanting the diffractive multifocal IOL in the dominant eye if the patient frequently performs near-distance work, and recommend implanting the refractive ReZoom in the dominant eye if the patient frequently performs intermediate-distance work. Implantation of the diffractive multifocal IOL to the dominant eye may be an option in special conditions.

In the present study, best patient-preferred reading distance was significantly closer in the Tecnis eyes. Reading speed can provide useful information regarding a patient's functional visual performance. In the current study, no statistically significant difference was found between the ReZoom- and Tecnis-implanted eyes in terms of reading speed. As expected, mean binocular reading speed was higher than monocular reading speed due to binocular summation. Chen et al.³⁶ and Hütz et al.³² also reported that "mix and match" eyes achieved satisfactory reading speed and reading acuity under both low

Table 5. The "mix and match" results of similar studies

Study	Multifocal IOL	Follow-up time (months)	Mean age (years)	Binocular UDVA	Binocular UIVA	Binocular UNVA	Spectacle independency (%)
Current study	ReZoom-Tecnis ZMA00	6	69.45 (31-86)	-0.05±0.09	0.1±0.05	0.1±0.05	100
Goes ^{31x}	ReZoom-Tecnis ZM900	2	58 (44-78)	0.0±0.2	0.3±0.05	-0.05±0.4	100
Hütz et al. ³²	ReZoom-Tecnis ZM900	3	72.1 (59-83)	0.08±0.07	∅	0.14±0.07	84-93
Lubiński et al. ³³	ReZoom-Tecnis ZM900	6	60.95 (42-70)	-0.18±0.08	0.01±0.03	0.0	100

^xIn the original study, results are given in decimal, UDVA: Uncorrected distance visual acuity, UIVA: Uncorrected intermediate visual acuity, UNVA: Uncorrected near visual acuity

and high illumination levels.

Buckhurst et al.³⁷ compared the defocus curves of 4 groups of 15 patients implanted with bilateral Softec monofocal IOL, bilateral ReZoom multifocal IOL, bilateral Tecnis ZM900 multifocal IOL, or “mix and match” with ReZoom implanted in the right eye and Tecnis ZM900 in the left eye. Best distance corrected intermediate visual acuity was significantly better in the ReZoom group when compared with the monofocal and Tecnis ZM900 groups, while there was no significant difference between the ReZoom group and the “mix and match” group. Best distance corrected near visual acuity was significantly better in the Tecnis group compared to the monofocal and ReZoom groups, whereas no significant difference was observed between the Tecnis group and the “mix and match” group. The “mix and match” group showed similar results to both the ReZoom and Tecnis groups. In the present study, we found a statistically significant superiority of the ReZoom eyes at -0.5 D (distance vision) whereas the Tecnis ZMA00 eyes were statistically better between -3.0 and -5.0 D (near vision). No statistically significant difference in intermediate vision was observed between the ReZoom- and Tecnis-implanted eyes. Binocular vision significantly outperformed the ReZoom-implanted eyes for near vision (-2.5 to -5.0 D) and the Tecnis-implanted eyes for distance and intermediate vision (+1.5 to -2.0 D). These results suggest that the “mix and match” approach provides the advantages of the both designs and enhances visual performance.

Multifocal IOL implantation can cause reduced contrast sensitivity, but this reduction does not appear to differ between diffractive and refractive multifocal IOLs.³⁸ However, Terwee et al.³⁹ showed that although the Tecnis ZM900 and ZMA00 models were not affected by pupil diameter, ReZoom NXG1 was affected by pupil diameter, and pupil dilation in low light resulted in decreased contrast sensitivity in ReZoom MIOL-implanted eyes. On the other hand, Yoon et al.³⁵ reported that there was no statistically significant difference between ReZoom NXG1 and Tecnis ZM900 multifocal IOLs under both photopic and mesopic conditions, and the contrast sensitivity levels were good both in low and high frequencies. In the present study, photopic and mesopic contrast sensitivity levels at all spatial frequencies were within normal limits in the ReZoom NXG1 and Tecnis ZMA00 eyes throughout follow-up. We observed that binocular contrast sensitivity levels were higher than those in ReZoom and Tecnis eyes, but the difference was not statistically significant. In Lubiński et al.'s study,³³ binocular distance photopic and mesopic and binocular near photopic contrast sensitivity levels were in normal limits even at high frequency. In addition, they stated that the binocular contrast sensitivity results were better at postoperative 6 months compared to results at 3 months.

Photic phenomena such as glare and halo occur as a result of multiple unfocused images.⁴⁰ In Goes's³¹ series, 12 of 20 patients reported photic symptoms and only one patient reported severe photic phenomena. Lubiński et al.³³

reported that none of the patients had severe halo or glare symptoms; however, 75% of the patients had some glare and halo phenomena, especially in low-light conditions. Hütz et al.³² also indicated that mild halos and severe glare were observed in 47% and 40% of their patients, respectively. Yoon et al.³⁵ reported that photic phenomena persisted in the unilateral groups, while the symptoms decreased over time in the bilateral “mix and match” group. They suggested that the lack of these photic phenomena in the phakic eyes of the unilateral group may have prevented their neuroadaptation to the new visual disturbances. In present study, 2 patients (10%) reported moderate, and 8 patients (40%) reported mild halo and glare symptoms at 6 months postoperatively. The patients expressed that the photic symptoms did not disturb them in their daily lives. The success of the multifocal IOL depends on the brain's neuroadaptation time.⁴¹ The long phase of neuroadaptation takes 3-12 months. Before final assessment of visual performance and patient satisfaction, it is important to allow sufficient time for neuroadaptation. None of our patients required explanation of multifocal IOL during follow-up.

In the current study, patient satisfaction was over 90% in terms of distance and near vision and social functions according to NEI VFQ-25 survey results. Satisfaction during driving was 97% among the patients who drove daily (n=10). Yamauchi et al.⁴² presented a visual performance comparison between bilateral implantation of the Tecnis monofocal IOL and Tecnis multifocal IOL (ZMA00/ZMB00). When the NEI VFQ-25 scores were evaluated, only nighttime driving score was significantly worse in the multifocal group than the monofocal group. In our study, 95% of the patients reported that their satisfaction from visual performances was “perfect or very good” and 95% stated that they would recommend this method to other patients. All of the studies using the “mix and match” approach have yielded high levels of patient satisfaction and spectacle independency.^{18,31,32,33} The “mix and match” approach can provide satisfactory results in selected patients who have realistic expectations and high motivation for a wide range of spectacle-free visual functions.

Study Limitation

A limitation of the present study is the lack of a control group of patients implanted with bilateral refractive and bilateral diffractive multifocal IOLs. Prospective, randomized, double-blind studies assessing bilateral refractive, bilateral diffractive, bilateral trifocal, and “mix and match” multifocal IOL implantation are needed.

Conclusion

In conclusion, the “mix and match” implantation of multifocal IOLs in conjunction with proper patient selection can be considered a good option for the correction of pseudophakic presbyopia. This approach can provide satisfactory visual acuity levels at all distances, high patient satisfaction, and

spectacle independence. The most important factors for high patient satisfaction are appropriate patient selection, correct IOL power calculation, and uneventful surgery.

Ethics

Ethics Committee Approval: Dokuz Eylül University Faculty of Medicine, Clinical and Laboratory Research Ethics Committee (confirmation number: B.30.2.DEÜ.0.01.00.00/9995).

Informed Consent: Available.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: Üzeyir Güneç, Revan Yıldırım Karabağ, Concept: Üzeyir Güneç, Hüseyin Aslankara, Design: Üzeyir Güneç, Hüseyin Aslankara, Data Collection or Processing: Revan Yıldırım Karabağ, Analysis or Interpretation: Üzeyir Güneç, Gül Arıkan, Revan Yıldırım Karabağ, Literature Search: Revan Yıldırım Karabağ, Rukiye Aydın, Writing: Revan Yıldırım Karabağ, Rukiye Aydın, Gül Arıkan.

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