(37)

Visual outcomes three and six months after implantation of diffractive and refractive multifocal IOL combinations

Ocena funkcji wzroku 3 i 6 miesięcy po wszczepieniu dyfrakcyjnej i refrakcyjnej soczewki wieloogniskowej w procedurze „mix and match"

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Summary:

Purpose: To evaluate 3 and 6 months binocular visual outcomes after cataract surgery using a multifocal IOL "mix and match" approach, with a refractive (ReZoom) IOL in the dominant eye and a diffractive (Tecnis) IOL in the fellow eye.

Material and methods: Three and 6 months after bilateral cataract surgery, 40 eyes of 20 patients were evaluated for binocular UDVA, UNVA and UIVA (logMAR), spectacle independence, contrast sensitivities (CS), stereoscopic vision, subjective symptoms, patient satisfaction and complications.

Results: Three months after surgery mean binocular UDVA did not differ from the six-month follow-up (-0.13 $\pm$ 0.08 vs. -0.18 $\pm$ 0.08; p = NS). All patients achieved binocular UNVA of 0.0 at both follow-ups. Mean binocular UIVA improved significantly from 0.06 to 0.01 ($p<0.027$), 6 months after surgery. All patients had very function at good visual all distances and were totally spectacle independent. CS under various conditions was within normal age-matched limits at both follow-ups. For some spatial frequencies six months postoperative results were significantly better than for the 3 months follow-up ($p<0.05$). Stereoscopic vision was normal. A low degree of glare/halo was detected in 75% of subjects. Overall patient satisfaction was very high (9.6/10). There were no postoperative complications.

Conclusions: Mixing and matching multifocal IOLs in selected cataract patients provides an excellent visual outcome, a high level of patient satisfaction and spectacle-free visual function. A period of neuroadaptation lasting at least six months is necessary to obtain better visual function results.

Key words: Cataract surgery, "mix and match" procedure, ReZoom IOL implantation, Tecnis IOL implantation, visual outcome, neuroadaptation.

Streszczenie:

Cel: ocena funkcji wzroku 3 i 6 miesięcy po operacji zaćmy ze wszczepem wieloogniskowej soczewki refrakcyjnej (ReZoom) do oka dominującego i dyfrakcyjnej (Tecnis) do oka przeciwległego z zastosowaniem zasady „mix and match".

Metody: w 40 oczach, u 20 kolejnych pacjentów, 3 i 6 miesięcy po obuocznej operacji zaćmy oceniono obuocznie UDVA, UNVA i UIVA (logMAR), niezależność od okularów, czułość kontrastową (CS), widzenie stereoskopowe, objawy niepożądane, stopień zadowolenia pacjenta i powikłania.

Wyniki: trzy miesiące po operacji średnia obuoczna UDVA nie różniła się od 6-miesięcznej obserwacji (-0.13 $\pm$ 0.08 vs -0.18 $\pm$ 0.08; p = NS). Wszyscy pacjenci osiągnęli obuoczną UNVA 0.0 w badaniach kontrolnych. Średnia obuoczna UIVA znacząco poprawiła się z 0.06 do 0.0 ($p<0.027$) 6 miesięcy po operacji. Wszyscy pacjenci uzyskali bardzo dobrą funkcję wzroku w różnych odległościach bez okularów i byli od nich całkowicie niezależni. CS w różnych adaptacjach mieściła się w granicach normy wiekowej. Sześć miesięcy po operacji dla niektórych częstotliwości przestrzennych wyniki CS były znacząco lepsze niż 3 miesiące po zabiegu ($p<0.05$). Widzenie stereoskopowe było prawidłowe. Niski stopień glare/halo został wykryty u 75% pacjentów. Ogólny stopień zadowolenia pacjentów był bardzo wysoki (9.6/10). Nie zaobserwowano powikłań pooperacyjnych.

Wnioski: zastosowanie wieloogniskowych soczewek zgodnie z zasadą „mix and match" u wybranych pacjentów z zaćmą przynosi doskonałe wyniki funkcji wzroku, wysoki stopień zadowolenia pacjenta i niezależność od okularów. Okres neuroadaptacji trwający przynajmniej 6 miesięcy jest konieczny do osiągnięcia lepszej funkcji oczu.

Słowa kluczowe: operacja zaćmy, procedura „mix and match", ReZoom IOL implantacja, Tecnis IOL implantacja, ocena funkcji wzroku, neuroadaptacja.

Introduction

Spectacle independence is a popular requirement of cataract surgery patients, as well as being an increasingly common expectation among refractive lens exchange patients. Bilaterally implanted multifocal refractive or diffractive IOLs have been successfully used to achieve a full range of vision (1). Spectacle-independence for near, intermediate and far vision can be achieved by implanting refractive lenses (ReZoom) (1-4) or diffractive lenses (i.e. Tecnis) (5,6) in both eyes, or by implanting a refractive lens in the dominant eye and a diffractive lens in the

non-dominant eye, which is commonly referred to as the "mix and match" approach (7-14).

To date, a small number of published studies suggest that mixing and matching refractive and diffractive multifocal IOLs in the same patient is the optimal way to provide excellent binocular vision at different distances, and to provide 100% of patients with spectacle independence (8-14).

In an effort to further evaluate these promising "mix and match" method results, we carried out a study in which we implanted a refractive IOL (ReZoom) in the dominant eye and a diffractive IOL (Tecnis ZM900) in the non-dominant eye of a selected group of cataract patients and then evaluated their binocular visual outcomes three and six months postoperatively.

Material and methods

The study comprised 40 eyes of 20 patients (14 females, 6 males), with a mean age of 60.95 years (ranging from 42 to 70 years), undergoing cataract surgery with implantation of a refractive multifocal IOL (ReZoom, Abbott Medical Optics, Santa Ana, CA), in the dominant eye and three weeks later a diffractive multifocal IOL (Tecnis ZM900, Abbott Medical Optics, Santa Ana, CA), in the non-dominant eye. As the ReZoom IOL is a distance-dominant lens, the study protocol required the implantation of this lens in the dominant eye. The dominant eye was determined via a pinhole test. All patients signed informed consent, and the study was performed in accordance with the Declaration of Helsinki.

Subjects were eligible for inclusion in the study if they were between 40 and 70 years of age, had bilateral cataracts, pupils with natural dilation of 3 mm or greater in both eyes in mesopic conditions and preoperative corneal astigmatism < 1.5 D (Corneal Videokeratography, Zeiss). They were also required to have a strong motivation for spectacle independence and be willing to comply with scheduled follow-up visits.

Exclusion criteria included ophthalmic disease, impaired ocular motility, pupil size < 3 mm in low light or > 6 mm in full light. Subjects were also excluded if they were satisfied with reading glasses, under 40 or over 70 years of age, had unrealistic visual outcome expectations, a profession that demanded visual precision (for example, watchmaker, architect), psychiatric disease, stroke, dyslexia, dissatisfaction with progressive glasses or the need for IOL power beyond the available diopter range (Tecnis $+5.0$ to $+34$, ReZoom $+6.0$ to $+30$).

Surgical technique

Target refraction was emmetropia, and IOL power calculations were performed using IOL Master (Carl Zeiss – Meditec, Jena, Germany; software version 2005), a-constant as recommended by the manufacturer with SRK-T formula. The same surgeon (W.L.) performed all procedures with in-the-capsular-bag placement through clear corneal temporal incisions (2.8-2.9 mm), under topical anesthesia. Continuous curvilinear capsulorhexis diameter was approximately 5 mm. The Tecnis ZM900 was inserted with the Silver Series Unfolder; ReZoom was inserted with the EmeraldT Unfolder (both Abbott Medical Optics, Santa Ana, CA). The Tecnis ZM900 is a three pieces foldable silicone IOL with a 6 mm, sharp-edged optic and CapC haptics with aspheric anterior surface. The posterior surface of this lens consists of 32 concentric circles with a $+4.00$ D near addition that splits the light entering the eye into two focal planes: for distance and for near. The ReZoom is a three-piece acrylic multifocal IOL with OptiEdge design that is claimed to minimize edge glare and the risk for PCO. The refractive surface has five optical zones with transition zones that are intended to improve intermediate vision. Near addition is equal to $+3.50$ D in the IOL plane. The IOL allows 100% light transmission in order to provide the full range of vision.

Outcome measures

Three and 6 months post operation, we evaluated patients for the following visual measures: binocular uncorrected distance visual acuity (UDVA) [logMAR – ETDRS chart (4 m)]; uncorrected near visual acuity (UNVA) [logMAR chart (40 cm)]; uncorrected intermediate visual acuity (UIVA) [logMAR chart (60 cm)]; spectacle independence; binocular photopic (85 cd/m^2), mesopic (3 cd/m^2) distance (2.5 m) and binocular photopic (85 cd/m^2) and near (35 cm) uncorrected contrast sensitivity (CS; 1.5, 3, 6, 12, 18 c/deg, CSV-1000, F.A.C.T.). We also conducted a screening stereoscopic test (Lang Stereotest II), and examined subjective symptoms and patient satisfaction [TyPE Questionnaire described by Leyland et al. (15)]. Pupil size under photopic and mesopic conditions was measured using the Colvard pupillometer (mean from three measurements with two examiners).

Statistical analysis

Statistical analysis of the results was performed using Statistica software. Visual acuity, CS, postoperative refraction and patient satisfaction results 3 and 6 months post operation were compared using the Wilcoxon test. A p value less than 0.05 was considered statistically significant.

Results

Before operation, 18 eyes were hyperopic ranging from $+1.00$ D to $+2.75$ D, with a mean spherical equivalent $+1.90 \pm 0.63$ D and a median of $+2.00$ D; 18 eyes were myopic ranging from -0.50 D to -1.50 D with a mean spherical equivalent of -1.21

Visual acuity mean/ Średnia ostrość wzroku	3 months/ 3 miesiące	6 months/ 6 miesięcy	p value/ wartość p
UDVA (logMAR)/ Nieskorygowana ostrość wzroku do dali	- 0.13 ± 0.08	- 0.18 ± 0.08	NS
UNVA (logMAR)/ Nieskorygowana ostrość wzroku do bliży	0.0	0.0	NS
UIVA (logMAR)/ Nieskorygowana pośrednia ostrość wzroku	0.06 ± 0.1	0.01 ± 0.03	**< 0.027**
CIVA (logMAR)/ Najlepiej skorygowana pośrednia ostrość wzroku	0.025 ± 0.04	0.0	NS

* NS – statistically not significant/ wynik nieistotny statystycznie

Tab. I. Mean binocular UDVA, UNVA, UIVA, CIVA 3 and 6 months after surgery.
Tab. I. Średnia obuoczna UDVA, UNVA, UIVA, CIVA 3 i 6 miesięcy po zabiegu.

ISSN 0023-2157 Index 362646

± 0.44 and a median of -1.25, the remaining four eyes were 0.00 D. For all eyes, the mean and median preoperative spherical equivalent refraction was +0.32 ± 1.57 D and 0.00 D, respectively. Mean preoperative binocular uncorrected distance visual acuity was logMAR 0.45 ± 0.18; mean preoperative binocular corrected visual acuity was logMAR 0.20 ± 0.26 (Tab. I).

At the three and six months postoperative intervals, the spherical equivalent for distance or near vision was 0.00 D. For intermediate vision three months post operation, five subjects needed spectacle correction ranging from -1.00 D to +1.25 D, and after correction, CIVA was logMAR 0.00 in four subjects and 0.1 in one subject. Six months after surgery, two subjects needed spectacle correction: one needed -0.50 D and the second +1.00 D; both attained logMAR 0.0 CIVA.

Distance and near vision

Six months after surgery, mean binocular uncorrected visual acuity for distance was better than at the three months follow-up (logMAR -0.18 ± 0.08 and -0.13 ± 0.08 respectively), albeit this difference was not statistically significant.

Three and six months post operation, mean binocular uncorrected near acuity was stable and equal to 0.00 (Tab. I).

Intermediate vision

Three months post operation, mean binocular UIVA was logMAR 0.06 ± 0.1. Binocular UIVA of 0.1 or better was achieved in 90% (18/20) of patients. Six months post operation, mean binocular UIVA was 0.01 ± 0.03 and significantly better than the three months follow-up outcomes ($p<0.027$). At the six months visit, binocular UIVA of logMAR 0.0 was achieved in 90% (18/20) of patients.

Three months post operation, mean binocular CIVA was logMAR 0.025 ± 0.04 (range 0.0-0.1). Binocular CIVA of 0.0 was attained in 75% (15/20) of patients. Six months postoperatively, mean binocular CIVA was 0.00 and better than the 3-month follow-up results (difference not statistically significant) (Tab. I).

Spectacle independence

Three and six months after surgery, all patients (20/20) had good spectacle-free visual function at all distances and reached the goal of spectacle independence.

Contrast sensitivity

Three and six months post operation, CS was found to be within normal limits compared with the normal population in the 50-75 years of age, range (16). This was true under various conditions: mean uncorrected binocular photopic (mean pupil size 3.67 ± 0.48 mm), and mesopic (mean pupil size 4.55 ± 0.68 mm), CS at distance as well as photopic near CS (Fig. 1).

Although being within normal limits at 3 months post operation, visual performance gained significant improvements under all conditions 6 months post operation (Tab. II). So, mean uncor-

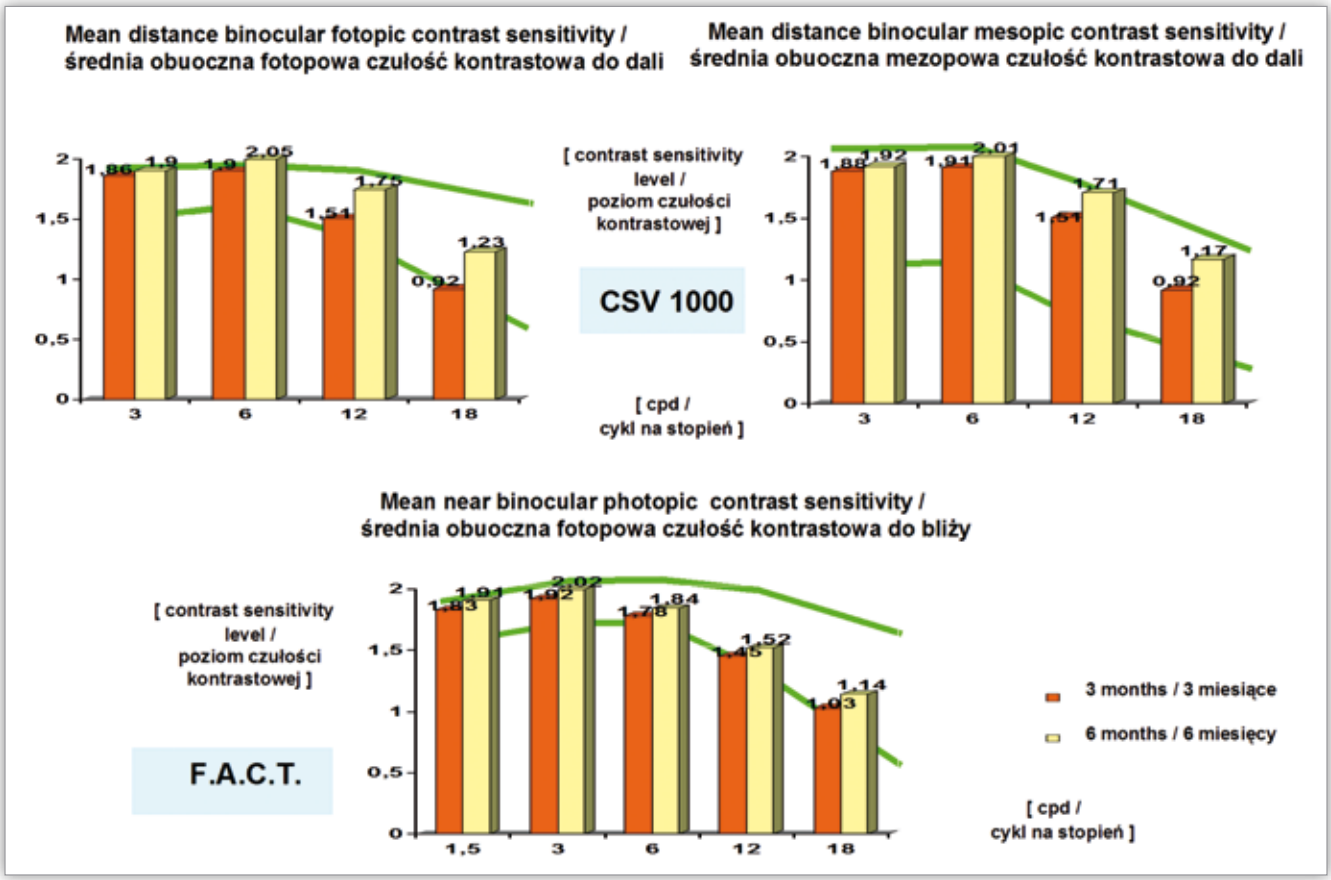

Fig. 1. Means of uncorrected binocular photopic, mesopic distance and photopic near CS, 3 and 6 months after surgery, in comparison to the normal population in the age of 50-75 years (green lines).

Ryc. 1. Średnie nieskorygowane obuoczne czułości kontrastowe: fotopowa, mezopowa do dali i fotopowa do bliży – 3 i 6 miesięcy po zabiegu w porównaniu z normą dla wieku 50-75 lat (zielone linie).

Question/ Pytanie	Possible answers/ Możliwe odpowiedzi	3 months/ 3 miesiące	6 months/ 6 miesięcy	p value/ wartość p
a. Work difficulty at near/ Trudności w pracy do bliży	(0 – 4)	0.35 ± 0.65	0.11 ± 0.31	NS
b. Work difficulty at distance/ Trudności w pracy do dali	(0 – 4)	0.20 ± 0.51	0.11± 0.31	NS
c. Work difficulty regarding glare/halo/ Trudności w pracy związane z glare/halo	(0 – 4)	0.15 ± 0.65	0.58 ± 1.04	NS
d. Level of glare/halo perception/ Poziom percepcji glare/halo	(0 – 4)	1.10 ± 0.99	1.42 ± 1.14	NS

* NS – statistically not significant / wynik nieistotny statystycznie

Tab. II. TyPE Questionnaire: Work difficulties in near and far distance (a, b); patient's perception of halo and glare/ patient´s disturbance by halo and glare (c, d) – comparison of 3 and 6 months after surgery (range 0-4: 0 = none, 4 = strong/severe).

Tab. II. Kwestionariusz zadowolenia pacjenta „TyPE": trudności w pracy do bliży i do dali (a, b); percepcja glare/halo/ trudności związane z glare/halo (c, d) – porównanie 3 i 6 miesięcy po zabiegu (zakres 0-4: 0 = bez trudności, 4 = mocno/ bardzo mocno wyrażone trudności).

rected binocular photopic distance CS was significantly better at 12 cpd (1.75 ± 0.25 vs 1.51 ± 0.25; $p<0.01$, and at 18 cpd (1.23 ± 0.27 vs 0.92 ± 0.25; $p<0.001$), in comparison to the 3 months follow-up (Tab. III a). Mean uncorrected binocular mesopic distance CS also improved significantly at 6 cpd (2.01 ± 0.21 vs 1.91 ± 0.19; $p< 0.033$), at 12 cpd (1.71 ± 0.27 vs 1.51 ± 0.25; $p< 0.020$), and at 18 cpd (1.17 ± 0.27 vs 0.92 ± 0.24; $p<0.002$) (Tab. III b).

Moreover, six months after surgery, the mean uncorrected binocular photopic near CS increased significantly at 1.5 cpd (1.91 ± 0.11 vs 1.83 ± 0.16; $p<0.05$), and at 3 cpd (2.02 ± 0.14 vs 1.92 ± 0.13; $p<0.016$) in comparison with the 3 months visit (Tab. III c).

Stereoscopic vision measured by the screening Lang Stereotest II test was normal at both the 3 and 6 months follow-ups.

Subjective symptoms

Three and six months post operation no significant daytime glare/halo was reported, but 75% of patients (15/20) reported low glare/halo perception mostly at night. No severe glare/halo was observed in any lighting condition. Three and six months post operation, work difficulties related to glare/halo were evaluated to be a small (0.15 ± 0.65 vs 0.58 ± 1.04), adverse effect and the level of glare/halo was considered low (1.10 ± 0.99 vs 1.42 ± 1.14) (Tab. II).

a

Photopic distance/ Fotopowa do dali	3 months/ 3 miesiące	6 months/ 6 miesięcy	p value/ wartość p
3 cpd	1.86 ± 0.12	1.90 ± 0.17	NS
6 cpd	1.90 ± 0.23	2.05 ± 0.21	NS
12 cpd	1.51 ± 0.25	1.75 ± 0.25	< 0.00973
18 cpd	0.92 ± 0.25	1.23 ± 0.27	< 0.000988

b

Mesopic distance/ Mezopowa do dali	3 months/ 3 miesiące	6 months/ 6 miesięcy	p value/ wartość p
3 cpd	1.88 ± 0.13	1.92 ± 0.16	NS
6 cpd	1.91 ± 0.19	2.01 ± 0.21	< 0.033055
12 cpd	1.51 ± 0.25	1.71 ± 0.27	< 0.020371
18 cpd	0.92 ± 0.24	1.17 ± 0.27	< 0.002587

c

Photopic near/ Fotopowa do bliży	3 months/ 3 miesiące	6 months/ 6 miesięcy	p value/ wartość p
1.5 cpd	1.83 ± 0.16	1.91 ± 0.11	< 0.046862
3 cpd	1.92 ± 0.13	2.02 ± 0.14	< 0.015912
6 cpd	1.78 ± 0.13	1.84 ± 0.16	NS
12 cpd	1.45 ± 0.19	1.52 ± 0.18	NS
18 cpd	1.03 ± 0.26	1.14 ± 0.13	NS

* NS – statistically not significant/ wynik nieistotny statystycznie

Tab. III. Mean uncorrected binocular photopic (a), mesopic (b) distance and photopic (c) near contrast sensitivity – 3 and 6 months comparison.

Tab. III. Średnia nieskorygowana obuoczna czułość kontrastowa: fotopowa (a), mezopowa do dali (b) i fotopowa do bliży (c) – porównanie 3 i 6 miesięcy po zabiegu.

ISSN 0023-2157 Index 362646

Question/ Pytanie	Possible answers/ Możliwe odpowiedzi	3 months/ 3 miesiące	6 months/ 6 miesięcy	p value/ wartość p
General vision satisfaction/ Ogólne zadowolenie pacjenta	(0 – 10)	9.40 ± 0.97	9.63 ± 0.66	NS
Near vision satisfaction/ Zadowolenie z widzenia do bliży	(0 – 10)	9.30 ± 1.00	9.58 ± 0.75	NS
Distance vision satisfaction/ Zadowolenie z widzenia do dali	(0 – 10)	9.50 ± 0.74	9.58 ± 0.67	NS

* NS – statistically not significant/ wynik nieistotny statystycznie

Tab. IV. TyPE Questionnaire – patient's satisfaction (binocular, unaided vision) – comparison of 3 and 6 months after surgery (range 0-10: 0 = not satisfied at all, 10 = completely satisfied).

Tab. IV. Kwestionariusz satysfakcji pacjenta „TyPE" (widzenie obuoczne, nieskorygowane) – porównanie wyników 3 i 6 miesięcy po zabiegu (zakres 0-10: 0 = niezadowolony z zabiegu, 10 = całkowicie zadowolony z zabiegu).

Patient satisfaction

Six months post operation general satisfaction with visual performance was very high (9.63 ± 0.66; scale 010) and did not differ significantly from satisfaction reported 3 months after surgery (9.4 ± 0.97) (Tab. IV). Six months after surgery, satisfaction with distance and near vision, as well as work difficulties for near and distance visual tasks improved slightly in comparison to the 3 months follow-up evaluation, but this difference was not statistically significant (Tab. II, IV).

Complications

No intraoperative or early postoperative complications were observed, and three and six months after surgery there were no postoperative complications.

Discussion

In recent years, surgeons have gained the ability to provide spectacle-free vision at all distances for selected cataract and refractive lens exchange patients by implanting a combination of refractive and diffractive multifocal intraocular lenses in a single patient. This approach – known as "mix and match" – arose from the knowledge that every multifocal IOL technology has some limitations. Neither refractive nor diffractive IOLs can fulfill a patient's need for perfect vision at all distances. For instance, in a study of 2500 implanted multifocal IOLs, Akaishi found that the strength of the ReZoom refractive lens is to provide excellent distance vision and very good intermediate vision, while the full diffractive Tecnis IOL provides excellent distance and near vision (17).

The different optical properties of the lenses are responsible for their limitations, as well as their strengths. For instance, the optic properties of the Tecnis IOL enable it to function independently of pupil size, in contrast to the ReZoom IOL. These distinct optical properties inspired the concept of combining refractive and diffractive lenses to maximize the patient's range of vision, and this novel approach was first introduced by Gunenc in 2003 (10).

Despite mounting evidence, it remains unproven whether mixing and matching refractive and diffractive lenses in the same patient is the best approach to achieve satisfactory, binocular vision at all distances. In order to gain further insight, we set up this study based on implantation of the ReZoom IOL in the dominant eye and a Tecnis IOL in the non-dominant eye. Our study, presented here, has achieved promising results.

In all patients (20/20) UDVA equaled -logMAR 0.13 at 3 months and did not change 6 months post operation. UNVA was very good (logMAR 0.0) and stable throughout the 6 months observation period. Three months after surgery, UIVA was also very good (mean logMAR 0.06) and improved significantly at the 6 months follow-up interval (mean logMAR 0.01). Ninety percent of patients achieved UIVA of 0.0, and all subjects achieved spectacle-free visual function.

Visual acuity outcomes in our study were comparable to those reported by Akaishi (11) (15 patients) and Goes (2) (20 patients) who both performed "mix and match" studies with the Tecnis/ReZoom combination. Each achieved good uncorrected visual results at near, intermediate and distance and a high degree of spectacle independence and patient satisfaction. Lopez-Castro (12) (31 patients) also found very good results for visual function at near, intermediate and distance in mesopic conditions after mixing and matching Tecnis/ReZoom lenses. However, only 85% of patients in the Castro study achieved spectacle independence.

When assessing visual outcome of "mix and match" approaches in comparison with bilateral implantation of the same MIOL, Bucci (13) 39 patients, Akaishi (11), and Goes (8) achieved better visual results especially at intermediate distances in patients with the combination of ReZoom/ReSTOR or Tecnis/ReZoom, than for a series of patients that received ReSTOR or Tecnis ZM900 lenses bilaterally. Total spectacle independence was not observed in patients with bilateral implantation of the diffractive AcrySof IQ ReSTOR SN6AD1 with a +3.00 add power (78% of patients spectacle free). However, intermediate vision was better than for the AcrySof IQ ReSTOR SN6AD3 with a +4.00 D add power (18).

It is well known that implantation of refractive and diffractive multifocal IOLs can result in reduced CS (12) and the reduction does not appear to differ between these two types of IOLs (19). In our series of patients, 3 months after surgery, binocular distance photopic and mesopic, as well as near photopic, CS was within normal limits in comparison with the normal population ranging in age from 50 to 75 years, even at higher spatial frequencies. It is worth mentioning that 6 months after surgery binocular distance photopic, mesopic and photopic near CS increased significantly for some cpd in comparison with the 3 months results (Fig. 1, Tab. III). Very good CS results were also noted in "mix and match" patients in a study by Gunenc et al. (7). In his study, patients from the "mix and match" group were binocularly tested and data revealed no significant difference with the binocular photopic CS of phakic and monofocal pseudophakic controls except at 18 cpd. The CS results were also significantly better than those of the diffractive and refrac-

tive eyes at each spatial frequency except at 18 cpd. Jakobi and Eisenmann (20) described an asymmetrical bilateral multifocal IOL implantation procedure in which one eye was implanted with a near dominant multifocal IOL and a far dominant multifocal IOL was implanted in the fellow eye. This procedure was based on the hypothesis that the image at the dominant focus of both eyes will be additive, and that consequently binocular CS and visual acuity at near and distance will be superior to the function in bilateral multifocal IOL combinations, that offer symmetrical light distribution. Using a similar concept and the "mix and match" approach, Jacobi et al. (21) also reported improved CS and visual acuity with combined asymmetrical diffractive multifocal IOLs.

Stereopsis (3D vision) is the ability of the binocular optical system to merge two images from each of the slightly disparate parallax points of view of each eye. In patients with multifocal IOL implantation, surgery disrupts the perception that is required for successful merging of these two images. The success of the multifocal IOLs depends on the brain's ability to adapt to new optical conditions. The normal results of stereoscopic vision measured by Lang Stereotest II test in our series of patients suggest that neuroadaptation is possible for patients who have multifocal IOLs implanted with the "mix and match" approach, and that this approach offers patients the opportunity to see objects precisely. Stereoscopic vision was also evaluated by Chen et al. (22) in patients with combined implantation of refractive (ReZoom) and diffractive (Tecnis) multifocal IOLs. They found in this group of patients that the acuity for near stereoscopy was significantly better than in a group of patients with bilateral monofocal Sensar AR40e IOL implantation.

In our study, general patient satisfaction was very high and stable. Six months post operation, satisfaction from distance and near vision improved slightly, although not statistically significantly (Tab. IV), and work difficulties at near and far distance diminished (Tab. II).

In patients with implanted multifocal IOLs, the causes of visual phenomena like glare and halo are multiple out of focus images (23). In our study, low glare/halo perception was observed in 75% of patients 3 and 6 months post surgery, but this observation refers almost universally to low-light conditions and no severe glare/halo was observed. Three and six months post operation, work difficulties connected with glare/halo were small, the level of glare/halo perception was low, and these evaluated parameters did not change significantly throughout the entire observation period (Tab. II). In our study, all patients accepted their visual phenomena and none of them wanted the multifocal lenses to be explanted. The visual disturbances did not affect normal activity during day or night.

Multifocal IOLs engage the simultaneous vision principle in which separate near and distance images are superimposed on the retina. The brain via the neuroadaptation process (synaptogenesis, neurogenesis) (24) selects an image related to the object that is being looked at and then suppresses the other image. Normal stereopsis in binocular vision is obtained because the brain is able to merge two disparate images from two eyes into one image with depth. The results of our presented study, which report total spectacle independence, low level of visual disturbances and good stereoscopic vision suggest that the brain can easily adapt to new optical conditions in patients who undergo multifocal IOL implantation with the "mix and match" approach. A significant improvement in intermediate visual acuity and CS 6 months post operation, in comparison to 3 months results, indicates that the neuroadaptation process lasts for more than a few months with these lenses, and can be responsible for better visual outcomes. This is also in line with results by Coskunseven (25) who assessed near and distance vision of the ReZoom IOL for up to 6 months. In that study a highly significant improvement in near vision was found at six months in comparison to 2 months results and was attributed by the authors to the brain's ability for neuroadaptation. Correspondingly, visual performance after multifocal IOL implantation might even gain significant benefit from functional vision training, as was shown for CS and near vision under different contrast levels by Mester et al. (26).

The results in the current series of patients are excellent and suggest that the "mix and match" approach is the best option for patients who desire a wide range of useful spectacle-free visual function. However, it seems to be important to allow patients' brains sufficient time for neuroadaptation before performing final assessments of visual function. According to our results it might be appropriate to judge on visual outcomes no earlier than 6 months after "mix and match" implantation.

Longer follow-up in a larger group of subjects is necessary to support this conclusion. Ultimately, the most important factors leading to spectacle independence are careful patient selection, uneventful surgery and precise IOL power calculation.

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The study was originally received 17. 02.2011 (1286)/
Praca wpłynęła do Redakcji 17. 02.2011 r. (1286)
Accepted for publication 14.07.2011/
Zakwalifikowano do druku 14.07.2011 r.

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