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Comparison of diffractive-refractive multifocal and accommodating intraocular lenses

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Keywords

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Abstract

Aims: To compare postoperative visual performance of a progressive-power diffractive-refractive multifocal and an accommodating intraocular lens in presbyopic patients.

Patients and Methods: The OptiVis multifocal IOL (Aaren Scientific, Ontario, CA) (MF group) was implanted into 9 eyes of 5 patients and Crystalens AT-50AO (Bausch & Lomb, Rochester, NY) accommodating IOL (AC group) was implanted into 10 eyes of 8 patients during phacoemulsification cataract surgery.

Uncorrected and best corrected distance, intermediate and near visual acuity, tilt and decentration of intraocular lenses, and total and higher-order aberrations of the eye were measured 6 months after surgery.

Results: There was no statistically significant difference between the two groups regarding age, axial length as well as difference between planned and postoperative manifest refraction (dPMR). In the MF group, both uncorrected distance (MF: 0.80±0.2 and AC: 0.55±0.30; p=0.004) and uncorrected near visual acuity (MF: 0.80±0.35 and AC: 0.60±0.30; p=0.045) were significantly better than in the AC group. No significant difference was found between the two groups in intermediate visual acuity (MF: 1.0±0.25 and AC: 1.0±0.30; p=0,341). Best corrected near, intermediate and distance visual acuity was 1.0 in both study groups. No significant differences were noted between the two groups in postoperative IOL tilt and decentration. The amount of the higher-order aberrations (RMS-HO) was significantly higher in the MF group compared to the AC group (0.43±0.20 μm vs. 0.285±0.10 μm; p=0.027). Postoperative manifest refraction values were significantly higher in the AC than in the MF group (MF:-0.5±0.75 D vs. AC:-1.06±0.88 D; p=0.032).

Conclusions: Better uncorrected distance and near visual acuity could be achieved with multifocal than with accommodating intraocular lenses, but higher-order aberrations were significantly higher with multifocal lenses.

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Introduction

Restoring accommodation resulting from presbyopia remains to be one of the major challenges in ophthalmology. Decreased accommodative ability arises not only from anatomical but physiological aberration as well. Possible mechanisms that may contribute to presbyopia include decreased elasticity of the crystalline lens, alterations in the elastic layer of Bruch's membrane, fibrotic changes in ciliary muscle thickness, changes in the vitreous body and circumferential enlargement of the crystalline lens (1). The accommodative amplitude begins to decrease already in childhood, whereas symptoms typically appear around the ages of 40-45 (2).

Implantation of intraocular lenses (IOLs) is a possibility to treat presbyopia.The two main lines are represented by multifocal („pseudoaccommodating") and so-called accommodating intraocular lens designs. The accommodating IOLs try to imitate the function of the crystalline lens. They are designed to transmit ciliary muscle contraction into a change of dioptric power of the lens. Multifocal (3) and accommodating (4) intraocular lenses have become more and more popular recently (5).

The purpose of our prospective study was the comparison of the postoperative visual performance with a progressive-optic refractive and diffractive multifocal IOL and an accommodating IOL.

Patients and Methods

This prospective, randomized study included 19 eyes of 11 patients (4 men, 8 women).

All patients underwent a thorough discussion with the surgeon about the risks, benefits, and alternatives of the treatment. The study was conducted in compliance with the Declaration of Helsinki and was approved by the local Ethics Committee. Inclusion criteria were senile cataract and age 50 years or older. Exclusion criteria were amblyopia, corneal astigmatism over 1.0 D, corneal diseases, non-dilating-pupil, microphthalmos, glaucoma, uveitis, retinal diseases, previous ocular surgery and trauma and axial length <19.0 mm or >25.0 mm. The OptiVis™ multifocal IOL (Aaren Scientific, Ontario, USA) was implanted into 9 eyes of 5 patients, and the Crystalens AT-50 AO (Bausch & Lomb, Rochester, NY) accommodating IOL was implanted in 10 eyes of 8 patients during cataract surgery using phacoemulsification without complications. The OptiVis™ IOL features a central 1.5 mm progressive-power refractive zone, designed to provide distance and intermediate vision, and a diffractive near annulus from 1.5 to 3.8 mm, as well as a peripheral distance zone (6).

Table 1: Demographic data of patients (*Mann-Whitney U test).

Parameter	MF Group (Median± Interquartile)	AC Group (Median± Interquartile)	P Value*
Eyes (n)	10	9	
Age (y)	56.0±4.0	64.5±11.0	0.060
Axial Length (mm)	22.1±0.35	23.06±1.01	0.052

No statistically significant differences were between groups in patient age or axial length (Table 1). Keratometry and axial length were measured using the LenStar LS 900 (Haag-Streit International, Koeniz, Switzerland). The SRK/T formula with an A-constant of 119.1 was used for IOL power calculations for eyes with axial lengths ≥22.01 mm. The Holladay II formula was used for eyes with axial length ≤22.0 mm and for eyes with K flatter than 42.00 D independent of axial length. The target refraction was emmetropia in all cases.

Surgical technique

All surgeries were performed by the same surgeon (Z.Z.N.), using topical anesthesia (oxybuprocain). Pupils were dilated with one drop of tropicamide 0.5% every 15 minutes for 45 minutes preoperatively. After creating a clear corneal incision (2.8 mm; created with a disposable keratome), viscoelastic material (Provisc, Alcon Laboratories Inc, Fort Worth, USA) was injected and then continuous curvilinear capsulorhexis (CCC) was performed using a rhexis forceps. Apart from the sizing of the CCC there was no difference in the surgeries of the two study groups. In the case of the AC group, the diameter of the CCC had to be 5.5 mm (7) to prevent the anterior capsule covering the optics of the AC intraocular lens. In the case of the MF group, a smaller, 4.75 mm (6) CCC was created to achieve an overlap over the IOL optic, as a large or eccentric capsulorhexis increases the risk of postoperative IOL misalignment (8,9). The corneal wounds were left sutureless. Patients were instructed to instill one drop of dexamethasone 0.1%-tobramycin 0.3% (Tobradex, Alcon Laboratories Inc, Ft. Worth, TX) five times daily for 1 week and four times daily for the following week.

Postoperative assessment

Six months postoperatively, we measured uncorrected and spectacle-corrected distance, intermediate and near visual acuity. Uncorrected and spectacle-corrected near visual acuity was measured using a Rosenbaum-Jaeger reading chart at 35 cm, and intermediate visual acuity at 60 cm. The chart was directly illuminated by a 60 W lamp. Uncorrected and spectacle-corrected distance visual acuity was measured using a Snellen chart fro 6 m. Visual acuity values were converted in logarithmic scale for statistical analysis.

A Scheimpflug imaging system (Pentacam; Oculus Optikgeräte GmbH, Wetzlar, Germany) was used to evaluate IOL tilt and decentration according to de Castro et al (10) as follows: IOL decentration is obtained from the distance between the IOL center and pupillary axis. Positive horizontal coordinates stand for nasal in the right eye and temporal in the left eye. Positive vertical coordinates stand for superior decentration, and negative for inferior decentration. By eliminating positive and negative signs, the magnitude of horizontal and vertical decentration could be determined without reference to nasal/temporal and superior/inferior orientation, respectively. Regarding IOL tilt, positive tilt around the x-axis indicates that superior the superior edge of the IOL is moved forward and vice versa for negative tilt. Positive tilt around the y-axis means, in the right eye, nasal tilt and indicates that the nasal edge of the IOL is moved backward and vice versa for the negative tilt around the y-axis in the right eyes. A positive tilt around the y-axis stands for temporal tilt (nasal edge of the IOL moves forward) in left eyes. By eliminating positive and negative signs, the magnitude of horizontal and vertical tilt could be determined without reference to any orientation. The same examiner (K.K.) obtained the tilt and decentration measurements (11, 12). Whole eye wavefront aberrations (total (RMS) and higher-order root mean square (RMS-HO) were measured using a Hartmann-Shack sensor at 4.5 mm pupil diameter (WASCA: Carl Zeiss Meditec AG, Jena, Germany).

Statistical analysis

The statistical analyses were conducted using SPSS 9.0 (SPSS Inc., Chicago, USA) software. Since the distribution of parameters defined during postoperative examinations do not match the normal distribution according to the Shapiro-Wilks test, the comparison of the two study groups was performed using Mann Whitney U-test. The results are shown in median ±interquartile range values. The significance level was set at $p<.05$ in all statistical analyses.

Table 2: 6-month Postoperative Data of Eyes That Underwent Multifocal or Accomodating Lens Implantation (UDVA = uncorrected distance visual acuity, UIVA = uncorrected intermediate visual acuity, UNVA = uncorrected near visual acuity, RMS = total optical aberrations, RMS-HO = higher order aberrations, dPMR = difference between planned and manifest refraction; * Mann-Whitney U test)

Parameter	MF Group (Median± Interquartile)	AC Group (Median± Interquartile)	P Value*
UDVA	0.80±0.20	0.55±0.30	0.004
UIVA	1.0±0.25	1.0±0.30	0.341
UNVA	0.80±0.35	0.60±0.30	0.045
RMS (µm)		1.48±0.76	0.725±0.26
RMS-HO (µm)	0.43±0.20	0.285±0.10	0.027
dPMR (D)	0.62±0.28	0.71±0.52	0.491

Results

No intraoperative or postoperative complications occurred.

Table 2 shows visual acuities in decimal and RMS, RMS-HO and dPMR values of the two study groups at 6 months after surgery. In the MF group, uncorrected distance visual acuity was significantly better than in the AC group. No significant difference was found between the two groups regarding intermediate visual acuity. Uncorrected near visual acuity proved to be also better in the MF group. The spectacle-corrected near, intermediate and distance visual acuities were 1.0 in both groups. There was no significant difference concerning postoperative total optical aberrations (RMS) between the two groups. Concerning postoperative higher order aberrations (RMS-HO), the results of the AC group were significantly better compared to the MF group. No significant difference was found between the two groups in the dPMR. There was no significant difference in IOL tilt or decentration between the two groups (Table 3). Postoperative manifest refraction values were significantly higher in the AC than in the MF group (MF:-0.5±0.75 D vs. AC:-1.06±0,88 D; p=0,032).

Discussion

Our results regarding postoperative distance, intermediate and near visual acuity performance of these multifocal and accommodating intraocular lenses correspond to previous publications (6,11). After implantation of the progressive-power refractive/diffractive multifocal IOL, good distance, intermediate and near vision could be achieved without correction, whereas the accommodating IOL provided good distance and intermediate visual acuity only.

On the other hand, higher-order aberrations were higher with the multifocal IOL than with the accommodating IOL. These higher-order aberrations might be responsible for glare and halo phenomena (13,14). Based on this study a greater spectacle independence could be achieved by implanting multifocal intraocular lenses. We examined that apart from the

Table 3: Tilt and Decentration Parameters of Eyes That Underwent Multifocal or Accomodating Lens Implantation (*Mann-Whitney U test).

Parameter	MF Group (Median± Interquartile)	AC Group (Median± Interquartile)	P Value*
Tilt (°)			
Vertical	4.20±3.19	1.91±2.36	0.220
Horizontal	3.785±4.21	2.21±1.89	0.462
Decentration (µm)			
Vertical	80±70	80±140	0.437
Horizontal	150±100	95±170	0.347

above mentioned factors, what other parameters could affect postoperative vision quality results. Our results showed that there was no significant difference between the multifocal and the accommodating group in the dPMR. There was no significant difference in postoperative tilt or decentration of the intraocular lenses between the two study groups.

Conculsions

Our results show that a progressive-optic refractive/diffractive multifocal IOL results in better vision over a larger range and is therefore more likely to provide spectacle independence than an accommodating IOL. Our results draw attention to the importance of accurate patient information and selection.

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