

Comparison of Visual Function after Multifocal and Accommodative IOL Implantation

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Abstract

Purpose: To compare early visual function between patients undergoing phacoemulsification combined with multifocal and accommodative intraocular lens implantation.

Methods: A total of 112 patients with age-related cataract undergoing phacoemulsification in our hospital were recruited for this study and randomly assigned into multifocal (56 eyes; ZMA00 group) and accommodative (56 eyes; FLEX group) intraocular lens groups. Visual acuity and contrast sensitivity were statistically compared between the two groups.

Results: No significant difference was found in uncorrected distant visual acuity between the ZMA00 and FLEX groups at 1 week, or 1, 3, and 6 months after operation (all $P>0.05$). At postoperative 6 months, no statistical significance was noted in distant and intermediate best-corrected visual acuity or in contrast sensitivity between the two groups (all $P>0.05$). Patients in the ZMA00 group were superior to their counterparts in the FLEX group regarding near best corrected visual acuity, reading speed, and spectacle independence (all $P<0.05$).

Conclusion: ZMA00 and FLEX IOL implantation can provide excellent distant and intermediate visual acuity for patients with age-related cataract. ZMA00 IOL is superior to FLEX in terms of near visual acuity. (*Eye Science* 2014; 29:95–99)

Keywords: multifocal intraocular lens; accommodative intraocular lens; contrast sensitivity

The progress made in phacoemulsification, the widespread application of multiple novel intraocular lenses (IOLs), and the ever-increasing requirements of quality of life have extended the purpose of cataract surgery from mere eyesight restoration to provision of good visual acuity. Currently, the single focus IOL can only provide patients with the ability

to see an object clearly at a specific distance. Most patients therefore have only good far or near vision because they lack lens accommodation or zoom. Corrective glasses need to be worn when viewing a near object¹. Ophthalmologists are therefore interested in procedures that would provide good a full range of vision, avoid the need to wear glasses, and improve visual acuity. Consequently, multifocal and accommodative IOLs are now being widely applied in clinical settings. The multifocal IOL generates multiple focuses through different optical surfaces, while the accommodative IOL can shift the position of the focus via specific haptic designs. Previous studies¹ indicated that both multifocal and accommodative IOLs could properly resolve the loss of accommodation of a conventional monofocal IOL. However, which IOL provides a better effect remains to be further studied. This study was designed to compare the visual performance of multifocal and accommodative IOL, to provide clinical evidence for further studies.

Materials and methods

General data

Fifty-six patients (56 eyes) receiving phacoemulsification combined with multifocal IOL implantation (Tecnis ZMA00, AMO) and 56 (56 eyes) undergoing phacoemulsification combined with Tetraflex accommodative IOL implantation (FLEX, Lenstee) in our hospital between June 2012 and June 2013 were enrolled in this clinical trial. The ZMA00 group consisted of 28 males (28 eyes) and 28 females (28 eyes), aged 56–75 years old (64.4 ± 4.8 years on average); the FLEX group consisted of 27 males (27 eyes) and 29 females (29 eyes), aged between 55 and 73 years (65.3 ± 5.1 years on average). No statistical significance was noted between the two groups

regarding age and gender (both $P>0.05$).

Inclusion and exclusion criteria

Inclusion criteria were as follows: patients aged >55 years, diagnosed with age-related cataract with II – III hard nuclei by the Lens Opacities Classification System II (LOCS II), preoperative best-corrected distance vision acuity of the affected eye ≤ 0.4 , corneal astigmatism <1.50 D, pupil diameter 2.5-4.0 mm, axial length range from 22.0-25.0 mm, and the implanted IOL 18.0-24.0 D. Reduction of the postoperative use of glasses was a requirement.

Exclusion criteria included the following: patients diagnosed with different types of corneal diseases, glaucoma, retinal diseases, strabismus and ocular trauma, those with a history of intraocular surgery or requiring combined surgery, and those complicated with systemic lesions affecting clinical prognosis.

IOL calculation and surgical technique

Corneal astigmatism and curvature were evaluated with an IOL-Master and the axial length was measured by A-ultrasound, repeated three times. IOL power was calculated using the SRK-II formula. Postoperative corneal power of the operated eyes was set as 0-0.5 D. All surgeries were performed by the same physician. Phacoemulsification combined with IOL implantation was conducted under surface anesthesia. A 3.2 mm transparent corneal incision was made at the temporal side. Then a viscoelastic agent was injected into the anterior chamber. After a continuous curvilinear capsulorhexis was made with a diameter of approximately 5.0-5.5 mm in the middle, phacoemulsification was then performed, followed by IOL implantation. The residual viscoelastic agent was removed and the incision was closed.

Multiple complications such as lens capsular tearing, posterior capsular rupture, zonular dialysis, and iridoptosis occurred intraoperatively. After surgery, the operative eyes were covered by eye shades and treated with tobramycin and dexamethasone eye drops (ALCON) four times daily; the drops were gradually reduced to twice daily for 3 to 4 weeks.

Postoperative follow-up

Conventional slit-lamp microscopy, funduscopy, and non-contact tonometry were conducted postoperatively. All patients underwent naked distant, intermediate, and near visual acuity tests and corrected

distant and near acuity tests at postoperative 1 week and 1, 3, and 6 months. Reading speed and contrast sensitivity examinations were performed at postoperative 6 months.

Distant visual acuity was tested at a distance of 500 cm using a standard logarithm visual acuity chart and expressed as a Snellen fraction. Intermediate visual acuity was tested at a distance of 63 cm and near visual acuity at 40 cm. The "Mixed contrast cards for refractive surgery/multifocal lenses" chart was adopted. The measurement data were expressed as Snellen fractions and converted into logMAR for statistical analysis.

Reading speed was determined according to Radner reading charts. The patients were required to read a passage of approximately 600 Chinese characters in 12-point print size and a 1.5 line spacing. The highest reading rate per minute at the optimal reading distance was regarded as reading speed.

A contrast sensitivity lamphouse (Stereo optical, OPTECN6500) was used to measure the contrast sensitivity function of monocular near daytime vision, distant night vision, night vision plus glare, daytime vision, and daytime vision plus glare at 5 spatial frequencies (1.5, 3, 6, 12, and 18 cpd).

Statistical analysis

SPSS17.0 statistical software was utilized for data analysis. Normally distributed distant-, intermediate-, and near-visual acuity, contrast sensitivity and reading speed the two groups were statistically analyzed between using a *t*-test. Non-normally distributed data were compared by a rank sum test. The rate of class independence between the two groups was statistically compared using a *chi*-square test. A value of $P<0.05$ was considered as statistically significant.

Results

Uncorrected distance visual acuity

Uncorrected distance visual acuity for the two groups at postoperative 1 week, 1, 3, and 6 months is shown in Table 1. No statistical difference was observed for any time point (all $P>0.05$).

Full range vision

Full range vision including best-corrected distance visual acuity, and intermediate and near visual acuity under distant corrected status at postoperative 6

Table 1 Comparison of uncorrected distance vision acuity after implantation of multifocal (ZMA00) or accommodative (FLEX) intraocular lenses at postoperative 1 week, and 1, 3, and 6 months

Postoperative	ZMA00 group	FLEX group	P
1 week	0.73±0.27	0.74±0.34	0.957
1 month	0.77±0.13	0.78±0.21	0.533
3 months	0.76±0.17	0.79±0.15	0.184
6 months	0.78±0.18	0.79±0.17	0.445

months were statistically compared between the ZMA00 and FLEX groups. No statistically significant difference was found between the two groups regarding distant and intermediate visual acuity (both $P>0.05$). The near visual acuity was significantly better in the ZMA00 group than in the FLEX group ($P=0.012$). Detailed results are shown in Table 2.

Table 2 Comparison of distant, intermediate, and near visual acuity at postoperative 6 months after refractive correction with multifocal (ZMA00) or accommodative (FLEX) intraocular lenses

Postoperative	ZMA00 group	FLEX group	P
Distant visual acuity	0.91±0.16	0.91±0.19	0.485
Intermediate visual acuity	0.76±0.18	0.73±0.21	0.737
Near visual acuity	0.51±0.13	0.33±0.14	0.012

Contrast sensitivity

Comparisons of contrast sensitivity under near acuity+daytime vision, distant acuity+night vision+glare, distant acuity+daytime vision, distant acuity+daytime vision+glare between two groups are shown in Tables 3–7. No statistically significant difference was observed between the two groups in terms of contrast sensitivity (all $P>0.05$).

Table 3 Comparison of contrast sensitivity under distant acuity+daytime vision between multifocal (ZMA00) and accommodative (FLEX) intraocular lens groups

Group	Spatial frequency (Cpd)				
	1.5	3	6	12	12
ZMA00 group	1.45±0.34	1.23±0.37	0.61±0.42	0.43±0.51	0.24±0.58
FLEX group	1.39±0.31	1.28±0.41	0.62±0.48	0.42±0.56	0.21±0.61

$P > 0.05$; Cpd = cycles per degree

Reading speed

Reading speed tests at postoperative 6 months revealed a significantly higher reading speed for the ZMA00 group (198.8±10.1 words per minute) than

Table 4 Comparison of contrast sensitivity under distant acuity+daytime vision between multifocal (ZMA00) and accommodative (FLEX) intraocular lens groups

Group	Spatial frequency (Cpd)				
	1.5	3	6	12	18
ZMA00 group	1.71±0.21	1.87±0.28	1.76±0.26	1.43±0.37	0.87±0.58
FLEX group	1.79±0.28	1.82±0.34	1.75±0.41	1.43±0.49	0.90±0.62

$P > 0.05$; Cpd = cycles per degree

Table 5 Comparison of contrast sensitivity under distant acuity+daytime vision+glare between multifocal (ZMA00) and accommodative (FLEX) intraocular lens groups

Group	Spatial frequency (Cpd)				
	1.5	3	6	12	18
ZMA00 group	1.69±0.25	1.84±0.30	1.74±0.29	1.46±0.41	0.83±0.57
FLEX group	1.70±0.22	1.85±0.27	1.76±0.38	1.45±0.43	0.85±0.64

$P > 0.05$; Cpd = cycles per degree

Table 6 Comparison of contrast sensitivity under distant acuity+night vision between multifocal (ZMA00) and accommodative (FLEX) intraocular lens groups

Group	Spatial frequency (Cpd)				
	1.5	3	6	12	18
ZMA00 group	1.61±0.23	1.87±0.36	1.77±0.34	1.43±0.44	0.85±0.61
FLEX group	1.63±0.22	1.82±0.27	1.76±0.42	1.42±0.47	0.88±0.72

$P>0.05$; Cpd = cycles per degree

Table 7 Comparison of contrast sensitivity under distant acuity+glare between multifocal (ZMA00) and accommodative (FLEX) intraocular lens groups

Group	Spatial frequency (Cpd)				
	1.5	3	6	12	18
ZMA00 group	1.62±0.28	1.84±0.30	1.74±0.29	1.46±0.41	0.83±0.57
FLEX group	1.69±0.24	1.86±0.33	1.73±0.45	1.49±0.46	0.88±0.67

$P>0.05$; Cpd = cycles per degree

for the FLEX group (128.2±7.3 words per minute) ($P<0.05$).

Eyeglass independence rate and adverse optical symptoms

Subsequent follow-up at postoperative 6 months revealed a significantly higher eyeglass independence rate in the ZMA00 group (93.4%) than in the FLEX group (71.6%) ($\chi^2=8.765$, $P<0.001$). In the FLEX group, 28.4% of patients still had to wear glasses to view a near object.

Two patients in the ZMA00 group showed a mild degree of glare at postoperative 6 months and a mild halo was present in one eye in another patient, which were all tolerated by the patients. No optical symptoms were observed in the FLEX group during follow-up.

Discussion

The goal of phacoemulsification combined with IOL implantation has shifted from improving postoperative visual acuity to obtaining high-quality vision including accommodation and a decrease in dependence on eyeglasses. Multifocal and accommodative IOLs can enhance accommodation and thereby improve visual quality. Therefore, they are receiving widespread attention in clinical settings.

This clinical trial compared the early full range of vision and contrast sensitivity after multifocal (ZMA00) and accommodative IOL (FLEX) implantation. The findings indicated that both surgeries could yield relatively good improvements in uncorrected distance vision acuity, corrected distant acuity, and intermediate visual acuity under corrected distant acuity. No statistically significant differences were noted between the two groups, which was consistent with previous findings^{1,2}. At postoperative 6 months, the near visual acuity was better in the ZMA00 group than in the FLEX group, probably because of a shift in the FLEX IOL position leading to accommodation. The postoperative lens capsule gradually decreased the mobility of the lens optics and haptic designs³; thereby, the near visual acuity was lower in the FLEX group than in the ZMA00 group. Previous studies indicated that accommodative IOL implantation could yield an accommodation of (2.36 ± 0.28) D at postoperative 1-3 months and (1.90 ± 0.77) D at postoperative 6 months. The accommodation induced by accommodative IOL decreased with time, accompanied by a reduction in dependence on eyeglasses. Similar findings were obtained in studies using FLEX IOL^{4,5}. In the present study, approximately 1/3 of the patients in the FLEX group had to wear glasses at postoperative 6 months. The long-term efficacy of accommodative IOL implantation

upon near visual acuity remains to be determined.

Near-distance reading was a common demand of all patients in the current study. The reading speed was significantly faster in the ZMA00 group than in the FLEX group. Accommodative IOLs offer equally good distant and intermediate visual acuity, but accommodative implantation is inferior to multifocal IOL implantation in terms of near visual acuity, as it decreases the glass independence rate and reading speed. During the 6-month follow-up, no signs of glare or halo were observed in the FLEX group. In the ZMA00 group, two eyes had mild glare and one had a slight halo, which were tolerable. No intolerable symptoms were observed during the whole procedure and no IOL replacement was performed.

The human contrast sensitivity function shows a typical band-pass filter shape peaking at around 4 cycles per degree, with sensitivity dropping off either side of the peak. This tells us that the human visual system is most sensitive in detecting contrast differences occurring at 4 cycles per degree (i.e., at this spatial frequency, humans can detect lower contrast differences than at any other spatial frequency⁶). Compared with monofocal IOL, multifocal IOL implantation may decrease contrast sensitivity⁷⁻¹⁰. Technological progress has led to substantial improvements in the contrast sensitivity of the multifocal IOL¹¹. Better improvements are obtained with diffraction IOLs than with refraction and accommodative IOLs. In the present study, no significant difference was observed in contrast sensitivity between multifocal and accommodative IOLs when spatial frequency, illumination, and glare varied ($P > 0.05$), which is consistent with Tan's findings¹².

In general, age-related cataract patients presented equally good improvements in intermediate and distant acuity after ZMA00 or FLEX IOL implantation. The near visual acuity in the ZMA00 group was superior to that in the FLEX group. Similar contrast sensitivity was obtained in the two groups. Mild adverse optical symptoms were observed in the ZMA00 group. However, the long-term postoperative visual function between the two groups remains to be elucidated by a randomized clinical trial.

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