· Clinical research ·

Higher order aberrations in eyes implanted with aspheric *vs* spherical hydrophilic intraocular lenses

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Abstract

• AIM: To compare the effect of spherical and aspheric hydrophilic intraocular lenses (IOL) on postoperative higher order aberrations (HOA).

• METHODS: Uneventful phacoemulsification was performed in 78 eyes of 66 patients with implanting either spherical Softec or aspheric Ocuva lenses. Preoperative and postoperative 3rd month aberrometry was performed with Visx Wavescan aberrometer to be compared.

• RESULTS: There was no statistically significant difference between two groups. Postoperative root-mean-square (RMS) value of HOA: 0.27 ± 0.11 in Softec and 0.28 ± 0.13 in Ocuva group, spherical aberration (SA): 0.11 ± 0.07 in Softec and 0.11 ± 0.08 in Ocuva group.

• CONCLUSION: Aspheric Ocuva IOL seems not to have an advantage of decreasing postoperative HOA compared to spherical Softec IOL.

• KEYWORDS: higher order aberration; aspheric intraocular lens; wavefront aberration

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INTRODUCTION

In recent years, cataract surgery evolved in a state which provides lower complication rates, better visual outcome and more patient satisfaction. In parallel to these advancements, intraocular lens (IOL) technology provides more sophisticated design and materials. Nevertheless, patients underwent cataract surgery can still complain about visual symptoms such as reflections, halos and glare. These symptoms have been shown to be caused by higher order aberration (HOA). HOA such as coma and spherical aberration (SA) also decrease contrast sensitivity, thereby have a negative effect on quality of vision[1-5]. Aspheric IOL can be useful to overcome these visual side effects. In this study, we purposed to compare spherical and aspheric hydrophilic acrylic IOL in terms of their effect on HOA.

Table 1 Preoperative characteristics of spherical and aspheric IOL groups ($\bar{x} \pm s$)

Characteristics	Softec ($n=40$)	Ocuva ($n=38$)
Age	67.15 ± 7.23	69.39 ± 10.03
Gender(Male/Female)	19/21	12/26[a]
Keratometry(Diopter)	43.56 ± 1.66	43.66 ± 1.54
Cataract stage	2.33 ± 1.05	2.11 ± 0.89
IOL power	20.58 ± 2.56	21.29 ± 1.29

[a] $P<0.05$ *vs*Softec.

MATERIALS AND METHODS

Subjects Seventy-eight eyes of 66 patients who underwent phacoemulsification and hydrophilic acrylic IOL implantation were included in this prospective, randomized, comparative study from May 2010 to September 2010. Informed consent according to the tenets of the Declaration of Helsinki was obtained from each patient. Inclusion criterion was being performed non-complicated phacoemulsification and hydrophilic acrylic IOL implantation. Exclusion criteria were previous history of ocular surgery, any other corneal, uveal, or vitreoretinal disease which would probably affect optical quality of the eye. Also, eyes had complicated surgery, postoperative posterior capsular opacification, and more than 0.5mm IOL decentration were excluded from study. Preoperative characteristics of groups are shown in Table 1.

Methods Spherical and aspheric IOL groups were made up. In spherical IOL group, Softec I (Lenstec, USA) was used in 40 eyes. In aspheric IOL group, Ocuva A625 (VSY Biotechnology, Istanbul, Turkey) was used in 38 eyes. Both of the IOLs were made from 26% water content hydrophilic acrylic material. They have the same single piece design of biconvex optic and modified C style haptic with 0 degree angulation. Soflens has 12 overall and 5.75mm optic, whereas Ocuva has 12.5 overall and 6mm optic dimensions. Both of Soflens and Ocuva has a refractive index of 1.46. There was no statistically significant difference between two groups. Additionally, there was no statistically significant difference in terms of preoperative HOA as shown in Table 2. Preoperative aberrometry couldn't be performed in 4 eyes of Softec group, and 3 eyes of Ocuva group because of dense cataract. Phacoemulsification was performed under topical or sub-tenon's anesthesias through a 2.8mm clear corneal incision. After performing a 5-5.5mm capsulorhexis, the nucleus was fragmented with stop and chop technique. Irrigation-aspiration, polishing capsular bag, IOL implantation with a

Table 2 Pre-and postoperative comparison of aberrations in spherical and aspheric IOL groups ($\bar{x} \pm s$)

	Preoperation		Postoperation	
	Softec($n=36$)	Ocuva($n=35$)	Softec ($n=40$)	Ocuva ($n=38$)
Pupil diameter	-	-	4.54±0.72	4.67±0.77
RMS	6.23±4.22	8.08±4.87	0.65±0.34	0.60±0.24
Higher order RMS	0.21±0.16	0.20±0.17	0.27±0.11	0.28±0.13
Spherical	0.02±0.07	0.01±0.06	0.11±0.07	0.11±0.08
Coma	0.09±0.09	0.09±0.09	0.09±0.06	0.10±0.06
Trefoil	0.09±0.08	0.09±0.09	0.16±0.09	0.16±0.11

All $P>0.05$ between two groups.

2.4mm injection system, and corneal wound hydration were performed respectively. Aberrometry was performed via Visx Wavescan (Abbott, USA) aberrometer preoperatively and on postoperative 90th day with naturally dilated pupil under scotopic condition. Hence, it could be possible to measure functional status of HOA corresponding to those occurrence in real life of the patient.

Statistical Analysis Statistical analysis was performed with Statplus software (Analysoft, USA). Comparisons were made by Student *t*-test for normal distribution, and Mann-Whitney *U* test for vice versa. Correlation coefficients were calculated with Pearson correlation test for data with normal distribution, and Spearman correlation test for data without normal distribution. Two tailed distribution outcomes were accepted for *P* values. As some patients' HOA couldn't be measured preoperatively because of their dense cataract, their preoperative outcome couldn't be put in statistical analysis.

RESULTS

Correlation coefficient between pupil diameter and postoperative SA was found 0.72 ($P<0.0001$) in Lenstec, and 0.76 ($P<0.0001$) in Ocuva group. Between pupil diameter and root-mean-square value (RMS: represents the variation in height of the wavefront aberration from the reference plane) of HOA, this coefficient was 0.67 ($P<0.0001$) in Lenstec, and 0.78 ($P<0.0001$) in Ocuva group. Mean pupil diameter was 4.54±0.72mm in Lenstec, and 4.76±0.77mm in Ocuva group at the time of postoperative aberrometry. Difference wasn't significant ($P=0.452$). In both groups, eyes with smaller than 4.50mm pupils apparently had less SA. In Lenstec group 21 eyes had smaller than 4.50mm pupil. (P.D. ≤4.50mm) with a mean value of 0.06±0.04 SA and 19 eyes had wider than 4.50mm pupil (P.D. >4.50mm.) with a mean value of 0.16±0.06 SA. Difference was significant ($P<0.0001$, *t*-test). In Ocuva group, eyes with P.D. ≤4.50mm ($n=22$) had a mean value of 0.07±0.04 SA, whereas eyes with P.D. >4.50 ($n=16$) had 0.17±0.09 ($P<0.001$, *t*-test). There was no statistically significant difference between two groups in terms of postoperative total RMS, RMS value of HOA, spherical, coma, and trefoil aberrations (Table 2).

DISCUSSION

HOA, particularly SA of eye change with age[6-11]. The cornea has positive SA, which means peripheral rays are focused in front of the retina. Positive SA of the cornea remains throughout life. In young people, the crystalline lens compensates for this positive SA by its negative SA. With age, negative SA of crystalline lens fall into a shift of SA towards positive. This points up corneal positive SA, thereby causes problems such as decreased contrast sensitivity and glare[12]. To eliminate these symptoms, IOL manufacturers have been trying to develop IOL which would compensate for positive SA of cornea simulating a young crystalline lens. Acrysof IQ SN60WF and Technis Z9000 are conspicuous aspheric IOL in terms of decreasing HOA in previous studies. Awwad *et al*[13,14], and Sandowal *et al* in 2008, reported that Acrysof IQ SN60WF causes less postoperative SA compared to Acrysof SN60AT. In Rekas' *et al*[15] study, either of eyes with natural crystalline lens and eyes implanted Acrysof IQ SN60WF had less postoperative SA than those implanted spherical Acrysof SN60AT. Rocha *et al*[16] found Acrysof IQ SN60WF to cause lower values of HOAs than AMO Sensar and Acrysof Natural both of which are spherical IOL. Like Acrysof IQ SN60WF, Tecnis Z9000 aspheric IOL manufactured by AMO has been reported to cause less postoperative SA compared to spherical IOL[17-19]. These are well known hydrophobic IOL proved by several studies to be beneficial in terms of reducing HOA. But there isn't enough information about effect of aspheric and spherical hydrophilic IOL on HOA. Taking into account that hydrophilic materials in the IOL sector may be approaching one third of the market in Europe, it should be informative to investigate effects of such prevalently used IOL. In this study, spherical and aspheric hydrophilic IOL are compared in terms of their effect on HOA. Unlike formerly adverted hydrophobic IOL, there was no statistically significant difference in postoperative spherical, coma and trefoil aberrations. And no difference in total and higher order RMS values.

As both groups' median value of pupil diameter were 4.5mm, either of the groups separated into two subdivisions from the median value of 4.5mm pupil diameter (P.D. ≤4.5mm, and P.D. >4.5mm) and compared in terms of SA. In both aspheric and spherical groups, eyes with P.D. >4.5mm had more SA than eyes with P.D. ≤4.5mm(In aspheric group: $P<0.001$, in spherical group: $P<0.0001$). Aspheric

Ocuva IOL seems to be more affected from pupil diameter than spherical Lenstec IOL according to correlation coefficients which could be judged as a contradictory finding for an aspheric IOL. Dietze and Cox[20] showed that more than 0.5mm decentration of aspheric IOL could cause more aberration than spherical IOL. For this reason, it could be reasonable avoiding aspheric IOL in cases likely to develop IOL decentration such as severe pseudoexpholiation or traumatic zonular dialysis. In this study, we didn't see IOL decentration more than 0.5 mm and had no finding about this issue. It has to be mentioned that HOA do not represent total quality of vision, and more measurements such as contrast sensitivity, modulation transfer factor, *etc*. are necessary to assess quality of vision. In conclusion, aspheric Ocuva IOL doesn't seem to cause less HOA compared to spherical Softec lenses. As hydrophilic IOL accounts for one third of the market (excluding United States), they need to be more investigated by further studies to get distinct knowledge on their effect on HOA.

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亲水性非球面与球面人工晶状体植入术后高阶像差的研究

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摘要

目的:比较亲水性球面和非球面人工晶状体(intraocular lenses, IOL)对术后高阶像差(higher order aberrations, HOA)的影响。

方法:66 例 78 眼行白内障超声乳化术并顺利植入球面 Softec 或者非球面 Ocuva 人工晶状体。术前和术后第 3mo 使用 VISX Wavescan 像差计进行像差测量与比较。

结果:两组间统计学无显著性差异。术后的高阶像差均方根值(root-mean-square, RMS):Softec 组 0.27 ± 0.11, Ocuva 组 0.28 ± 0.13,球面像差(spherical aberration, SA):Softec 组 0.11 ± 0.07,Ocuva 组 0.11 ± 0.08。

结论:与球面 Softec 人工晶状体比较,Ocuva 非球面人工晶状体似乎没有减少术后高阶像差的优势。

关键词:高阶像差;非球面人工晶状体;波前像差