Acta Scientific Ophthalmology (ISSN: 2582-3191)

Volume 3 Issue 11 November 2020

Research Article

Comparison of Optical Quality, Spherical Aberration and Contrast Sensitivity between Spherical and Aspheric Intraocular Lenses

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Received: September 17, 2020

Published: October 07, 2020

Abstract

Background: The goal of cataract surgery today is not only to restore visual acuity but also to provide the best quality of vision possible. With modern techniques and advancements in the manufacture of Intra Ocular Lenses (IOLs), improvement in patients' visual performance and quality of life has become the main goals after cataract surgery.

Method: 70 eyes of 70 patients (35 aspheric IOL and 35 spherical IOL) between the age group of 45 - 73 years with BCVA of 6/6 at postoperative period of 3 months were enrolled in the study. HD -Analyzer was used to measure the optical quality, FACT for checking the contrast sensitivity and i-Trace for measuring the spherical aberration. Informed consent was obtained from all participants. For each case Pro Forma sheet including patient's demographic data, best corrected visual acuity and type of IOL implanted were maintained.

Results: There was significant better contrast sensitivity, optical quality and less of spherical aberration in patient who were implanted with aspheric IOL than compare to the patients implanted with spherical IOL.

Conclusion: After the postoperative period of 3 months, patient with aspheric IOL were found to have good optical quality, contrast sensitivity and reduced spherical aberration than those of spherical IOL group.

Keywords: Optical Quality; Contrast Sensitivity; Spherical Aberration; Spherical IOL and Aspheric IOL

Abbreviations

ACIOL: Anterior Chamber Intraocular Lens; BCVA: Best Corrected Visual Acuity; cpd: Cycles Per Degree; D: Dioptre; FACT: Functional Acuity Contrast Test; HOA: Higher Order Aberration; IOL: Intraocular Lens; mm: Millimeter; µ: Micron; OSI: Optical Scatter Index; OQAS: Optical Quality Analysis System; PCIOL: Posterior Chamber Intraocular Lens; SA: Spherical Aberration; SE: Spherical Equivalent

Introduction

Any opacity of the lens or its capsule causing visual impairment is called cataract [1]. Nowadays, with improvement in manufacturing new IOLs, patients' visual performance and quality of life has become the main goals after phacoemulsification [2]. The goal of cataract surgery today is not only to restore visual acuity but also to provide the best quality of visual functions possible.

Aberration is defined as a defect in a lens where the light is not focused to the point, but is spread out over some region of space [3] and hence an image formed by the lens with aberration is blurred or distorted, with the nature of the distortion depending on the type of aberration.

i- Trace is the instrument used to measure the optical aberration. By combining corneal topography with wavefront aberrometry, this instrument isolates the internal aberration of the eye by subtracting corneal from the total aberration [4].

The optical errors caused by the element of the optical apparatus of the eye, such as cornea or lens strongly degrades the image on retina which leads to the decrease in the optical quality of eye.

The quality of vision in a patient can be measured by using HD-analyzer. It is based on double-pass technique and is considered useful in more objective estimation of real retinal image quality after cataract surgery which is difficult to explain simply by measuring visual acuity [5]. This system yields excellent repeatability and good reproducibility for objective measurement of overall optical quality [6].

Contrast sensitivity is the ability to distinguish an object from its background. Contrast is measure of difference between the luminance of an object on the luminance of the area surrounding it [7]. Contrast sensitivity testing gives the measure to help assess the patient's visual need and was measured by using FACT.

Materials and Methods

The study was done in Nethradhama Superspeciality Eye Hospital, Bangalore, India from January 2018 to June 2018. This study was conducted as randomized, prospective, cross sectional study. 35 eyes with spherical IOL and 35 eyes with aspheric IOL of age ranged 45 - 73 years (males and females) were enrolled in the study. Inclusion criteria being BCVA of 6/6, age group considered, patients with aspheric and spherical IOL implanted and exclusion criteria being pupil anomalies, dry eye, anisometropia, retinal and corneal abnormalities, any previous ocular surgery, surgical complication, systemic disease potentially affecting vision and miotic (< 4 mm) and large pupil (> 4 mm). A detailed history with demographic data of each individual was recorded. The subjects underwent all other preliminary ophthalmic examination including, slit lamp examination and ophthalmoscopy, applanation tonometry, corneal topography to rule out any ocular pathology.

Intraocular lens implantation

The spherical IOL was compared to the aspheric IOL in this randomized, prospective, cross sectional study after the postoperative period of three months. The surgery was performed using posterior chamber phacoemulsification with foldable IOL under topical anesthesia, with a very small incision of 2.8 mm temporally and the surgery was performed by same surgeon. In all patient IOL was implanted in the capsular bag, once in place the lens unfolds to it's regular size of 6 mm.

Characteristics	Aspheric IOL	Spherical IOL
Total design	Single piece	Single piece
Optic material	UV blocking; hydrophobic acrylic	UV-blocking hydrophobic acrylic
Optic design	Biconvex, anterior aspheric surface, square optic edge	ProTEC frosted, continuous 360º posterior square edge
Overall length	13.0 mm	13.0 mm
Optic size	6.0 mm	6.0 mm
Refractive index	1.47	1.47
Haptic material	UV blocking; hydrophobic acrylic	UV-blocking hydrophobic acrylic
Haptic design	Haptic offset from optic	Haptic offset from optic
A constant	118.8	118.4

Table 1: IOLs specifications.

Contrast sensitivity measurement

Contrast sensitivity was measured in mesopic condition (6 cd/m^2) by using FACT chart (Ginsburg Box, VSCR-CST-6500; Vision Science Research Corporation, Walnut Creek, CA, USA) at spatial frequency values of 1.5, 3, 6, 12, 18 cycles per degree. Contrast sensitivity measurement was taken with patient's best refractive correction. In this test, the patient was instructed to look at a distance of 3 meter on the chart and was asked to identify and locate the direction of vertical sinusoidal grating in the chart. Tests for contrast sensitivity were not recorded for the first time and were repeated for several times to ensure reproducibility of results. Eyes were not dilated for the contrast sensitivity test and therefore pupil size was normal.

Optical quality measurement

Optical quality was measured by using HD- analyzer (Visiometrics; OQAS - HDA). Patient's chin was placed on the chin rest and forehead on the forehead strap. The patient was asked to look at the fixation target, image was captured and the data were taken. The manifest refractive error of the subjects were corrected fully; the spherical error (up to -8.00Ds) were corrected automatically by double-pass system, and the residual spherical error (-8.00Ds) as well as cylindrical error were corrected with an external lens because the uncorrected refractive error affects directly the optical outcome of the system.

Spherical aberration measurement

Spherical aberration was measured using i-trace (HOYA) with pupil size of 4 mm. If the pupil diameter was less than 4mm, tropicamide 1% eye drops were applied to dilate the pupil. Patient's chin was placed on the chin rest and forehead on the forehead strap. The patient was asked to look at the fixation target and further image was captured and the data were taken.

Statistical analysis

Statistical analysis was done by using SPSS 1.0. The groups were compared using the paired sample t-test for variables like spherical aberration, contrast sensitivity and optical quality. P-values of < 0.05 were considered statistically significant.

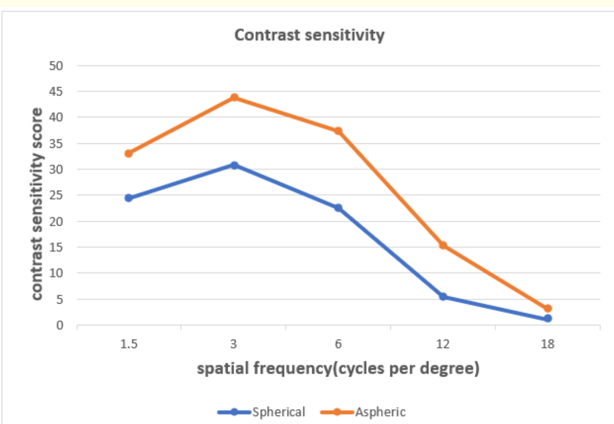
Results

A total of 70 eyes of 70 patients were included, 35 eyes were implanted with spherical IOL and 35 eyes with aspheric IOL. The mean age of 55.7 ± 5.9 years (range, 45.0 - 73.0 years).

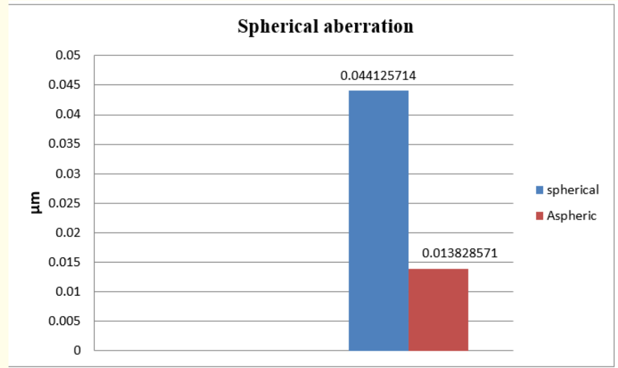
After cataract surgery, spherical aberration in pseudophakic condition and pupil diameter of 4mm was significantly lower in eyes with aspheric IOLs compared to spherical P < 0.05 (Paired t test table 3).

Average contrast sensitivity under mesopic conditions (6 cd/m^2) [10] was better in aspheric IOLs when compared to spherical IOLs. P = 0.015 (Paired t test table 4).

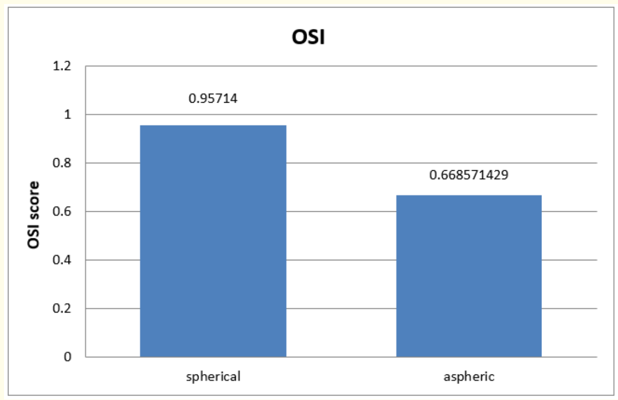
OSI measured by using HD - Analyzer showed significant greater scattering in spherical IOL compared to aspheric IOLs P = 0.001 (paired t test table 5).



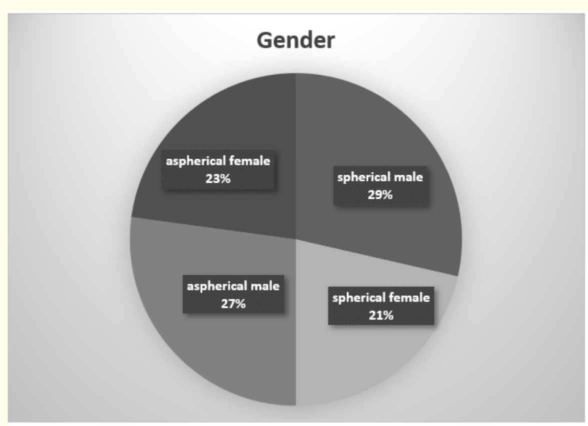
Graph 1: Contrast sensitivity in patients with spherical and aspheric IOL under mesopic condition (6 cd/m^2).



Graph 2: Postoperative spherical aberration with spherical and aspheric IOL.



Graph 3: Postoperative OSI between spherical and aspheric IOL.



Graph 4: Gender distribution in spherical and aspheric IOL.

Variables	Spherical	Aspheric	P value
Age (year)	61.64 ± 8.19	61.22 ± 8.25	0.799
IOL Power	21.22 ± 2.45	21.34 ± 1.97	0.840
SE at postoperative day of 3 months	-0.18 ± 0.51	0.0036 ± 0.45	0.122

Table 2: Patients characteristics in each group (n = 70).

Spherical aberration (μm)		
	Mean ± SD	P
Spherical IOL	0.0441 ± 0.03559	0.000027
Aspheric IOL	0.0138 ± 0.01144	

Table 3: Spherical aberration in spherical and aspheric IOL (n = 70).

Variables	Aspheric	Spherical	P value
CS at frequency of 1.5 cpd	33.17 ± 4.88	24.40 ± 3.927	0.00 (< 0.05)
CS at frequency of 3 cpd	43.74 ± 12.85	30.86 ± 11.51	0.004
CS at frequency of 6 cpd	37.4 ± 13.58	22.60 ± 7.36	0.00 (< 0.05)
CS at frequency of 12 cpd	15.47 ± 6.37	5.44 ± 4.16	0.00 (< 0.05)
CS at frequency of 18 cpd	3.29 ± 3.97	1.18 ± 1.85	0.009

Table 4: Contrast sensitivity in eyes with spherical and aspheric IOLs at in mesopic condition and spatial frequencies of 1.5, 3, 6, 12 and 18 cpd.

OSI		
	Mean ± SD	P
Spherical IOL	0.9571 ± 0.41818	0.001
Aspheric IOL	0.6686 ± 0.30367	

Table 5: Ocular scatter index in spherical and aspheric IOL.

Discussion

In our study, spherical aberration after cataract surgery was found significantly less in eyes implanted with aspheric IOLs compared to the spherical group. Other studies have shown the same significant lower spherical aberration in eyes with aspherical IOLs [8,9]. With increase in the age, spherical aberration of the crystalline lens turns to be positive and with the addition of lens aberration to the corneal aberration leads to increase in the total aberration of the eye [11]. Conventional spherical IOL introduce only positive spherical aberration causing decrease in image quality whereas aspherical IOL with negative spherical aberration compensate for the positive spherical aberration of cornea producing minimal spherical aberration [12,13]. Complain of glare, haloes in pseudophakic patient is due to spherical aberration [14]. There was a significant difference between spherical and aspheric IOL in terms of contrast sensitivity in mesopic condition and contrast was found better in aspheric IOL in our study. In the previous study of Jiraskova., *et al*. they have also found significant differences between aspheric and spherical IOLs in terms of contrast sensitivity at mesopic levels [9]. Mohammad Nasser Hashemian., *et al*. concluded that contrast sensitivity was better in aspheric lenses when compared to spherical lenses in all spatial frequencies except the frequency of 20 cpd [8]. In the study of Chen Y., *et al*. they concluded that OSI value was significantly lower in aspherical lens compared with spherical lens [15]. Similar result was found in our study. This study shows that objective visual quality of aspheric lens is better than that of spherical lens by means of OQAS.

Conclusion

We concluded that, aspherical IOL was better than the spherical IOL in terms of optical quality, contrast sensitivity in all spatial frequencies (1.5 cpd, 3 cpd, 6 cpd, 12 cpd, 18 cpd) and also the spherical aberration was found to be significantly lower in aspheric IOL than compared to the spherical IOL.

Acknowledgement

We thank Mr. Nirmal Debnath M. Optom, Mr. Sharath N S, B Optom, Nethradhama school of optometry, Nethradhama superspeciality eye hospital, Bangalore.

Conflict of Interest

Nil.

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