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Original article

Distribution of corneal and ocular spherical aberrations in eyes with cataract in the Taiwanese population

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ABSTRACT

Purpose: To investigate the distribution of corneal and ocular spherical aberrations (SAs) in eyes with cataract in the Taiwanese population.
Methods: Corneal and ocular SAs were measured in the central 6-mm optical zone using wavefront aberrometry. Axial length (AL) and keratometry (K) were also evaluated in each eye.
Results: A total of 413 eyes in 234 patients were analyzed. The mean age of the patients was 66.8 ± 10.64 years. The mean AL and K values were 24.32 mm and 44.08 D, respectively. The mean corneal SA was 0.307 ± 0.135 μm and ocular SA was −0.042 ± 0.487 μm. Ocular and corneal SAs were significantly correlated ($r^2 = 0.04$, $p < 0.001$). Corneal and ocular SAs were not significantly correlated with K ($p = 0.096$ and $p = 0.634$, respectively), but were significantly correlated with AL ($p < 0.001$). Multilinear regression showed that corneal SAs and age were the dependent variables that predicted ocular SAs ($r^2 = 0.143$, $F = 13.65$, $p < 0.01$), especially in patients who were aged > 50 years, for whom a strongly significant positive correlation was found ($r^2 = 0.102$, $F = 11.10$, $p < 0.001$).
Conclusion: Corneal and ocular SAs varied among cataract patients and correlated with AL. After 50 years of age, ocular SAs increased significantly because of an increase in internal (lenticular) SAs. Corneal SAs in Taiwanese patients were larger than those in Japanese patients and similar to those in Chinese and Malaysian populations. Preoperative measurement of wavefront aberrations is necessary to select which aspherical intraocular lenses are most suitable for achieving better postoperative visual quality.

1. Introduction

Optical aberrations of the eye can be divided into lower-order aberrations (LOAs) and higher-order aberrations (HOAs). Spherical aberration (SA) is a type of HOA and is caused by a difference in focus between central rays and peripheral rays that reach the retina at the same time. HOAs may interfere with visual quality by resulting in decreased contrast sensitivity, glare, and halos. Currently, the availability of wavefront-sensing devices in ophthalmic clinics has permitted a greater understanding of the impact of aberrations on vision. Advancements in cataract surgery and intraocular lens (IOL) design have made possible the customization of target refraction by appropriate IOL power selection. Moreover, aspherical IOLs have been designed to eliminate corneal SAs with substantial levels of success beyond visual acuity.[1,2]

The design of IOLs to reduce or eliminate SAs in pseudophakic eyes is based on compensating for the resulting corneal SA after removal of the crystalline lens.

Salmon and van de Pol[3] established the population norms of ocular aberrations in a large cohort of 2560 eyes. However, only 134 eyes were from an Asian population (Japan). Shimozono et al[4] reported the corneal SA values of a Japanese group, and Lim and Fam[5] reported the distribution of SA values in a Singaporean-Malaysian population. There was a large difference in corneal SA values between these two ethnic groups. Furthermore, age may play a role in ocular HOAs. Fujikado et al[6] reported that ocular HOAs increase significantly after the age of 50 years, but there was no correlation between age and corneal SAs. The aim of our study was to investigate corneal and ocular SAs (Zernike coefficient, Z_4^0) in a

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Table 1
Statistical results of 413 eyes in 234 patients.

	Mean ± SD	Range
Age (y)	66.80 ± 10.64	38.00 – 97.00
Axial length (mm)	24.32 ± 1.94	21.06 – 32.67
Keratometry (D)	44.08 ± 1.51	40.30 – 48.32
Corneal SA (μm)	0.307 ± 0.14	−0.200 – 0.840
Ocular SA (μm)	−0.042 ± 0.49	−3.100 – 2.180

SA = spherical aberration; SD = standard deviation.

Taiwanese population and to compare them with the findings of previously published studies.

2. Materials and methods

This retrospective study was comprised of patients with a diagnosis of senile or presenile cataract in Mackay Memorial Hospital from September 2011 to August 2012. All patients were Taiwanese, and they had cataracts that caused visual impairment with a best corrected visual acuity of <20/50. Patients with a history of corneal pathology or ocular surgery, but not of eyelid surgery, were excluded. Axial length (AL) and keratometry (K) were measured under regular room light conditions using partial coherence interferometry (IOL Master; Carl Zeiss Meditec AG, Jena, Germany), and all signal-to-noise ratios were ≥3. Eyes with previous ocular surgery and dense cataract that could not be measured using the IOL Master were also excluded.

Corneal and ocular SAs (Z_4^0) were obtained using the Wavefront Aberrometer (NIDEK OPD-Scan II ARK-10000; Gamagori, Aichi, Japan). This scanner is a multifunction instrument that integrates Placido-based corneal topography with wavefront aberrometry of the entire eye. The wavefront measuring apparatus is based on the principle of retinoscopy, which uses an infrared slit of light to scan all 360° meridians over a 6-mm pupil. The time difference of the reflected light to stimulate an array of photodetectors is translated to a refractive wavefront map.[7] Measurements were taken at the central 6-mm optic zone without mydriasis for all patients included in this study. The examination was performed by a single experienced technician.

The aberrations were tabulated in Excel 2007 (Microsoft, Inc., Redmond, WA, USA), and the analysis was performed using GraphPad Instat software (GraphPad Software, Inc., La Jolla, CA, USA). All parameters were normally distributed (passing the Kolmogorov–Smirnov test of normality); thus, linear regression and Pearson correlation coefficients (r) were used to compare groups and values. A multilinear regression model, consisting of ocular parameters associated with ocular SA, was tested. These parameters were age, K, corneal SA, and AL. A p value < 0.01 was considered statistically significant.

3. Results

We analyzed 413 eyes (OD eyes: 207; OS eyes: 206) in 234 patients (98 men; 136 women) with a diagnosis of cataract from September 2011 to August 2012. The mean [± standard deviation (SD)] age of the patients was 66.80 ± 10.64 years (range, 38–97 years). The mean AL was 24.32 mm [95% confidence interval (CI), 24.136–24.512 mm], and the mean K was 44.08 D (Table 1).

The mean corneal and ocular SAs were 0.307 ± 0.135 μm (range, −0.200–0.840 μm) and −0.042 ± 0.487 μm (range, −3.100–2.180 μm), respectively. The distribution of corneal SAs is shown in Fig. 1. Three eyes had negative corneal SAs, from −0.2 μm to −0.11 μm; all of the patients denied trauma or previous ocular surgeries, and no corneal deformities were found at slit lamp examination. The relationship between ocular and corneal SAs was statistically significant ($r^2 = 0.04$, $p < 0.001$). Corneal and ocular SAs were not significantly correlated with K ($p = 0.096$ and

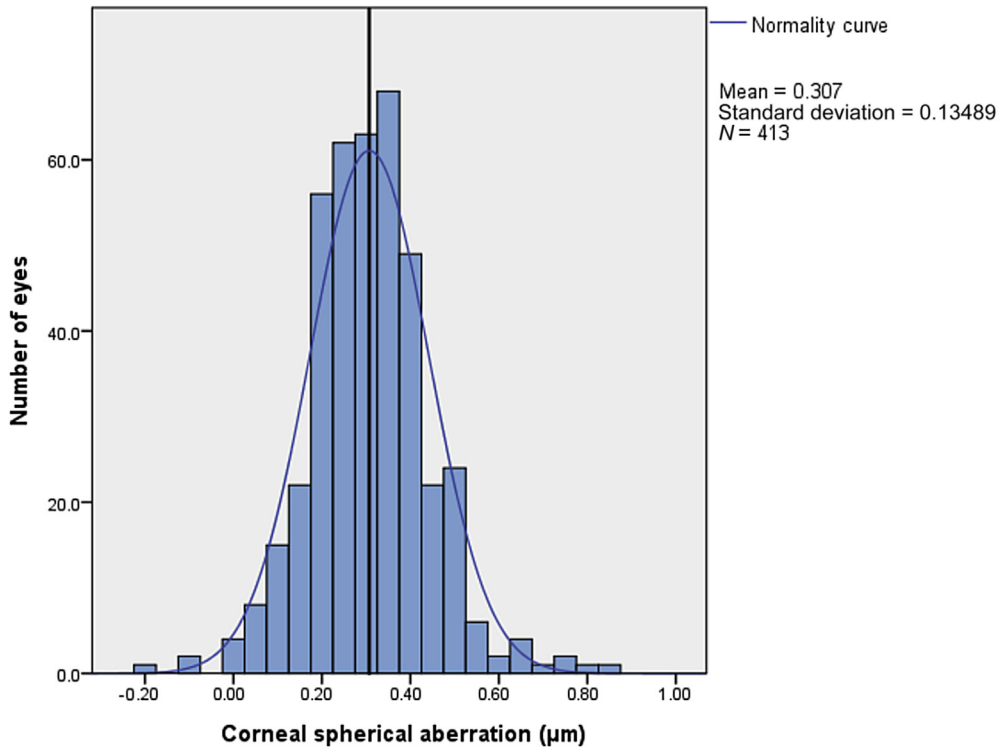

Fig. 1. Distribution of corneal spherical aberrations (Z_4^0) was compatible with normality distribution, despite three negative values. The mean Z_4^0 value of 0.307 ± 0.135 μm is represented by the thick solid line.