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Research Article

Accuracy of Intraocular Lens Refraction Measured by Optical Biometry and Acoustic Biometry in Eyes with Age-Related Macular Degeneration that Underwent Cataract Surgery

Izumi Yoshida, Masashi Sakamoto*, Takahiro Sodeno, Asao Sakai and Takatoshi Maeno

Department of Ophthalmology, Toho University Sakura Medical Center, Sakura-shi, Japan

***Corresponding Author:** Masashi Sakamoto, Department of Ophthalmology, Toho University Sakura Medical Center, Sakura-shi, Japan.

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Abstract

Purpose: We examined differences between preoperative predicted refractive values and postoperative refractive values calculated by using optical biometry and acoustic biometry for cataract surgery in patients with age-related macular degeneration.

Materials and Methods: In this retrospective comparative study, 21 eyes of 18 patients (male, 14 cases; female, four cases; age, 79.2 ± 5.5 years) with age-related macular degeneration and 17 eyes of 17 patients (male, 6 cases; female, 11 cases; age, 75.4 ± 13.2 years) without macular disease that underwent cataract surgery were included. The difference between the preoperative predicted refractive value and postoperative refractive value was examined and we compared values obtained by optical biometry with those obtained by acoustic biometry.

Results: The postoperative refractive error calculated by A-scan was -0.72 ± 0.96 diopters and that calculated by optic biometry was -0.13 ± 0.83 diopters in patients with age-related macular degeneration. Higher myopic shifts were observed with A-scan measurements than with optical biometry measurements.

Conclusion: Greater postoperative myopic shifts were observed when using A-scan values compared with values obtained using optic biometry in patients with age-related macular degeneration who underwent cataract surgery.

Keywords: *Age-related Macular Degeneration; Intraocular Lens Master®; A-scan Ultrasound; Refractive Error; Axial Length*

Abbreviations

AMD: Age-Related Macular Degeneration; CRT: Central Retinal Thickness; IOL: Intraocular Lens; logMAR: Logarithm of the Minimum Angle of Resolution; OCT: Optical Coherence Tomography; RPE: Retinal Pigment Epithelium; VEGF: Vascular Endothelial Growth Factor

Introduction

Patients who are treated for age-related macular degeneration (AMD) often have age-related cataract progression. While the outcomes of AMD treatment have improved with the development of anti-vascular endothelial growth factor (VEGF) drugs [1], the quality of cataract surgery is considered to be important in patients with AMD.

The predicted refraction before cataract surgery is currently measured by partial coherence laser interferometry and ultrasound A-scan biometry. Compared with acoustic biometry, optical biometry is reportedly more accurate in eyes with cataracts [2]. However, there is no report in which the predicted refractive error was examined in patients with AMD who underwent cataract surgery.

Aim of the Study

The aim of this study was to compare the accuracy of predicting refraction measured by the IOLMaster® (Carl Zeiss, Jena, Germany) versus A-scan biometry in patients with AMD who underwent cataract surgery.

Materials and Methods

In this retrospective, comparative study, 21 eyes of 18 patients (male, 14; female, four; age, 79.2 ± 5.5 years) with AMD and 17 eyes of 17 patients (male, six; female, 11; age, 75.4 ± 13.2 years) without macular disease who underwent cataract surgery performed by one doctor (I.Y.) at Toho University Sakura Medical Center between August 2014 and July 2017 were examined.

Axial length was measured by both A-scan ultrasonography (UD-6000, Tomay Corporation, Nagoya, Japan) and optic biometry (IOL-Master®, Carl Zeiss). Further, the retinal thickness of the macula was measured by optical coherence tomography (OCT; Zeiss Humphrey Systems, San Leandro, CA, USA). Postoperative refraction was measured at least 1 month after cataract surgery.

The axial length was measured before cataract surgery and postoperative refractive values were also measured. Central retinal thickness (CRT) was measured with OCT on the same day that the preoperative axial length was measured using both A-scan ultrasonography and optic biometry measurements and on the same day when the postoperative refractive value was measured.

Considering that the predicted refractive error might be caused by poor visual fixation, the patients with AMD were divided into patients with good visual acuity (eight cases) and patients with poor visual acuity (13 cases) before surgery. The boundary dividing the two groups was the mean logarithm of the minimum angle of resolution (logMAR) and equaled 0.89 for all patients with AMD.

The study protocol for this retrospective, observational, comparative study was reviewed and approved by the ethics committee at Toho University Sakura Medical Center (approval number: S18056). All study conduct adhered to the tenets of the Declaration of Helsinki and written informed consent was obtained from all subjects. Consent was obtained after the study design and participation risks and benefits were explained using the Toho University Sakura Medical Center website in accordance with the guidelines for clinical research established by the Japanese Ministry of Health, Labor, and Welfare.

All statistical analyses were performed using Statcel (OMS, Saitama, Japan) statistical software. Unpaired t-tests were used to compare refractive errors.

The differences in refractive error was compared between eyes with AMD and eyes without macular disease and using A-scan ultrasonography and optic biometry measurements. The Mann-Whitney U test was used to compare two materials.

Results and Discussion

Results

Table 1 shows the characteristics of the eyes in both groups. The mean age was 79.2 ± 5.5 years among eyes with AMD and 75.4 ± 13.2 years among eyes without macular disease (p = 0.28). The mean preoperative logMAR visual acuity was 0.90 ± 0.55 in patients with AMD and 0.88 ± 0.58 in patients without AMD (p = 0.55). The mean number of previous injections of anti-VEGF medication was 7.35 ± 5.75 in eyes with AMD. The postoperative logMAR visual acuities were 0.47 ± 0.38 and 0.094 ± 0.22 in eyes with and without AMD, respectively (p = 0.005).

	AMD	Without macular disease	P
Age (years)	79.2 ± 5.5	75.4 ± 13.2	0.28
Preoperative logMAR	0.899 ± 0.55	0.877 ± 0.58	0.55
Preoperative refraction value	-0.059 ± 2.14	-2.173 ± 3.45	0.047
Postoperative logMAR	0.470 ± 0.38	0.094 ± 0.22	0.005
Postoperative refraction value	-1.31 ± 1.25	-0.57 ± 0.91	0.063
Postoperative refractive error (A-scan)	-0.72 ± 0.96	-0.34 ± 0.87	0.318
Postoperative refractive error (IOLMaster)	-0.13 ± 0.83	0.29 ± 0.95	0.178

Table 1: *Patient and ocular characteristics in subjects with AMD and without macular disease.*

In patients with AMD, axial length could be measured by A-scan ultrasonography in all cases; however, we were unable to measure axial length by optic biometry in five cases because of a posterior subcapsular cataract or mature cataract [3]. In patients without macular disease, axial length could be measured by A-scan ultrasonography in all cases; however, we were unable to measure axial length by optic biometry in five cases.

The predicted refractive error calculated from A-scan ultrasonography in patients with AMD was -0.72 ± 0.96; it was -0.34 ± 0.87 in patients without macular disease. The predicted refractive error calculated from optic biometry in patients with AMD was -0.13 ± 0.83; it was 0.29 ± 0.95 in patients without macular disease.

The predicted refractive error in patients with AMD was not significant relative to patients without macular disease calculated by both optic biometry ($p = 0.178$) and A-scan ultrasonography ($p = 0.318$); however, the postoperative refractive value demonstrated a myopic shift in patients with AMD as calculated from both optic biometry and A-scan ultrasonography and the postoperative refractive value tended to show a greater myopic shift when calculated from A-scan ultrasonography (Table 1).

The mean CRT before cataract surgery in patients with AMD was 334.6 ± 124.8 µm. The mean CRT after cataract surgery was 362.8 ± 137.6 µm. The CRT was not significantly different between before and after cataract surgery ($p = 0.58$; Mann-Whitney U test).

Regarding the difference in visual acuity before cataract surgery, the predicted refractive error calculated by A-scan ultrasonography in patients with AMD and good preoperative visual acuity was -0.12 ± 0.35; it was -1.09 ± 1.03 in patients with AMD and poor preoperative visual acuity.

The predicted refractive error calculated by optic biometry in patients with AMD and good preoperative visual acuity was 0.21 ± 0.52; it was -0.48 ± 0.98 in patients with AMD and poor preoperative visual acuity. The predicted refractive error was significantly higher in patients with poor visual acuity calculated by A-scan ultrasonography ($p = 0.020$) and optic biometry ($p = 0.016$) relative to patients with good visual acuity

	Good visual acuity	Poor visual acuity	P
Preoperative logMAR	0.41 ± 0.19	1.33 ± 0.24	0.0003
Refractive error measured by A-scan	-0.12 ± 0.35	-1.09 ± 1.03	0.02
Refractive error measured by IOLMaster	0.21 ± 0.52	-0.48 ± 0.98	0.016
CRT (preoperative - postoperative)	0.63 ± 28.24	52.56 ± 122.77	0.58

Table 2: *Postoperative refractive error in patients with good or poor visual acuity and AMD.*

Discussion

Cataract surgery is beneficial for patients with coexisting advanced AMD, even though they have worse postoperative visual acuity compared with eyes without macular disease. Pham*., et al*. stated that progressive AMD was associated with poor visual outcomes after cataract surgery [4]. Conversely, there are studies that reported positive visual outcomes in patients with advanced AMD after cataract surgery [5-8].

The postoperative refractive value after cataract surgery is considered to be important in patients with AMD. The IOLMaster® is a non-contact device that measures to the back of the retinal pigment epithelium (RPE) layer and uses a fixation beam, which assists in measuring along the visual axis. On the other hand, axial length is obtained by A-scan ultrasonography by using the signal from the internal limiting membrane.

The major factor influencing intraocular lens (IOL) calculation is the axial length measurement [9]. Based on estimations using the Sanders-Retzlaff-Kraff formula, an error of 100 µm in axial length can lead to an error of 0.25 diopters (D) in IOL power [9]. In eyes with macular diseases, the increased retinal thickness can cause an underestimation of the cornea-photoreceptor layer distance, which can result in a postoperative myopic shift [9,10].

Ueda., *et al.* reported a significant difference between axial length measured using A-scan ultrasonography and optic biometry in patients with macular edema; the IOLMaster® was sufficient for measuring axial length in eyes with macular edema and for reducing postoperative refractive errors [11].

The CRT in patients with AMD changes easily with the degree of AMD progression. The CRT might affect the axial length measurement, similar to macular edema. If the CRT in patients with AMD is high when the axial length is measured, the axial length measured by A-scan ultrasonography might be underestimated compared to the actual axial length. In the current study, the difference in CRT between before cataract surgery and after cataract surgery was not significant; thus, it might not affect the measurement of axial length.

On the other hand, because the IOLMaster® measures back to the RPE layer, the preoperative predicted refractive error might be considered to be lower relative to A-scan ultrasonography. In the current study, the predicted refractive error calculated by both optic biometry and A-scan ultrasonography in patients with AMD was not significant relative to patients without macular disease; however, the postoperative refractive value demonstrated a myopic shift in patients with AMD calculated by both optic biometry and A-scan ultrasonography, and the refractive value tended to have a greater myopic shift when calculated by A-scan ultrasonography relative to optic biometry.

The myopic shift in the postoperative refractive value is considered to be the result of the axial length being overestimated relative to the actual axial length. Generally, the axial length measured by IOLMaster® was not accurate in patients with poor fixation [12]. This might lead to a predicted refractive value with a myopic shift even when measured by IOLMaster® because patients with AMD have poor fixation.

In the current study, the refractive value tended to show a greater myopic shift when calculated by A-scan ultrasonography because an A-scan generally detects an area of 0.3 mm^2, which is larger than the area used in optic biometry measurement (0.05 mm^2); thus, A-scan ultrasonography may measure the macula in a different position [10]. This might lead to the axial length being estimated as longer than the actual axial length calculated by A-scan ultrasonography relative to optic biometry in patients with AMD that might have poor fixation.

Regarding the difference in visual acuity from before cataract surgery, the predicted refractive error was more significant in patients with poor visual acuity calculated by A-scan ultrasonography and optic biometry relative to those with good visual acuity. The difference in the predicted refractive error might be caused by the patients' poor fixation because the axial length might be overestimated by A-scan ultrasonography because the received A-scan signal chosen by the technician might come from an area of the normal retina that displays a better A-scan signal compared with the macula with AMD.

The predicted error was significantly different between patients with poor and good visual acuity before cataract surgery as calculated by the IOLMaster®. Poor fixation due to poor visual acuity might affect the result, even if it is measured by optic biometry.

Our study has several limitations. In the current study, the distance between the cornea and RPE layer was not examined, which affects the axial length measurement by IOLMaster® between before and after cataract surgery. Further study is needed in which the cornea-RPE layer distance is examined more comprehensively using OCT. Studies on IOL positioning reported that during the first postoperative week, the IOL moves slightly forward, which is neutralized by a slight backward movement within 3 months [13]. The follow-up period of the current study was less than 1 month; perhaps if the follow-up period was longer, the refractive error might have changed in this study. Further studies with longer follow-up periods are needed.

Conclusion

In patients with AMD, the postoperative refractive value might demonstrate a myopic shift when calculated by both A-scan ultrasonography and optic biometry.

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Conflict of Interest

The authors declare no conflicts of interest.

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