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Research Article

Accuracy of Intraocular Lens Refraction Measured by Optical and Acoustic Biometry in Eyes after Phacovitrectomy for Rhegmatogenous Retinal Detachment

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Received: November 29, 2018; **Published:** December 27, 2018

Abstract

Purpose: To investigate the accuracy of two predictive measures of postoperative refraction, IOL master® and A-scan ultrasound, in eyes after phacovitrectomy for rhegmatogenous retinal detachment.

Methods: We conducted a retrospective comparative study, including patients (97 cases, 64 males, 33 females, mean age 60.2 ± 8.4) with rhegmatogenous retinal detachment (RD), who underwent phacovitrectomy at Toho University Sakura Medical Center between April 2015 and May 2018. We included only patients with follow-up ≧ 1 month after surgery. We excluded patients where encircling or local scleral buckling were additionally performed, fixed intraocular lens on the capsule was applied or where axial length could not be measured by both A-scan and IOL master. We subdivided patients into two groups: RD with macula involvement (35 patients) and RD without macula involvement (62 patients). We compared postoperative refractive outcomes to the predicted refractive outcomes as measured by both IOL master and A-scan.

Results: The mean postoperative prediction error of RD with macula involvement was -1.09 ± 0.64 diopters as measured by IOL master and -1.32 ± 1.19 diopters as measured by A-scan. The mean postoperative prediction error of RD without macula involvement was –0.55 ± 0.77 diopters as measured by IOL master and -0.91 ± 0.78 diopters as measured by A-scan.

Conclusion: Predictive error is higher when measured with A-scan than with IOL master in cases where phacovitrectomy was performed for RRD, despite macula involvement. Predictive refraction error is particularly higher in patients with RD with macula involvement when measured both with A-scan or IOL master.

Keywords: *Rhegmatogenous Retinal Detachment; Phacovitrectomy; A-scan Ultrasound; Intraocular Lens Master®; Predictive Error*

Introduction

Phacovitrectomy has recently begun to be performed in rhegmatogenous retinal detachment (RD) because development of cataract after vitrectomy is common [1]. In addition, pars plana vitrectomy is more difficult to perform in phakic eyes [2-5].

If the lens is removed during surgery, primary and secondary intraocular lens (IOL) implantation can be considered. Secondary IOL implantation is associated with more accurate IOL power calculations when compared to primary IOL implantation because the retina is attached. However, patients require at least two surgeries to improve retinal detachment.

Thus, primary IOL implantation during vitrectomy for RD has become a commonly used procedure [3-5]. However, measurements of axial length by A-scan and IOL master® might not be accurate in RD patients, especially in those with macula involvement, because retinal detachment is typically associated with shortening of the axial length.

Hence, in this study, we sought to compare the accuracy of predicting refraction measured by IOL master® and A-scan in patients with RD.

Patients and Methodology

We conducted a retrospective comparative study, including patients (97 cases, 64 males, 33 females, mean age 60.2 ± 8.4) with rhegmatogenous retinal detachment (RD), who underwent phacovitrectomy at Toho University Sakura Medical Center between April 2015 and May 2018. The study protocol for this retrospective, observational and comparative study was reviewed and approved by the ethics committee at Toho University Sakura Medical Center (approval number No. S18083). All study procedures were performed in accordance with the Declaration of Helsinki. Written informed consent was obtained from all subjects. Consent was obtained after the study's procedures and participation's risks/benefits were explained, in accordance with the guidelines for clinical research set out by the Japanese Ministry of Health, Labor, and Welfare.

We included only patients with follow-up ≧ 1month after surgery. We excluded patients in whom encircling or local scleral buckling were additionally performed, fixed intraocular lens on the capsule was applied or where axial length could not be measured by both A-scan and IOL master. We subdivided patients into two groups: RD with macula involvement (35 patients) and RD without macula involvement (62 patients). We compared postoperative refractive outcomes to the predicted refractive outcomes as measured by both IOL master and A-scan. RD with macula involvement was determined by fundus examination and optical coherence tomography.

We considered that the location of RD may affect the axial length measured by A-scan, because the cases of incipient RD of the inferior side shifts the retina more inferiorly when the patient is measured at an upright position and in the cases of incipient RD of the superior side the detached retina tends to move closer to the macula. Hence, we subdivided cases with macula involvement into two groups: RD of the superior and RD of the inferior side. Thereafter, we compared postoperative refractive values to the predicted refractive values, which were obtained by performing measurements using both IOL master® and A-scan. Postoperative refraction was measured at least 1 month after vitrectomy.

All statistical analyses were performed using Statcel (OMS, Saitama, Japan) statistical software. F-tests were used to compare refractive errors among groups. Statistical significance was defined as $P < 0.05$.

Results and Discussion

The mean postoperative prediction error of RD with macula involvement was -1.09 ± 0.64 diopters as measured by IOL master and -1.32 ± 1.19 diopters as measured by A-scan. The mean postoperative prediction error of RD without macula involvement was -0.55 ± 0.77 diopters as measured by IOL master and -0.91 ± 0.78 diopters as measured by A-scan. There were no differences in measured refractive error between IOL master and A-scan neither in RD cases without macula involvement (P = 0.97) nor in cases with macula involvement (P = 0.98).

The mean postoperative predictive error in cases of incipient RD of the superior side and with macula involvement was -1.08 ± 1.32 diopters as measured by IOL master and -1.23 ± 1.39 diopters as measured by A-scan. The mean postoperative prediction error in cases of incipient RD of the inferior side and with macula involvement was -1.10 ± 0.64 diopters as measured by IOL master and -1.50 ± 0.51 diopters as measured by A-scan. Refractive error in the cases of incipient RD of the inferior side was significantly higher than that of the superior side when measured both by A-Scan (P = 0.003) and by IOL master (P = 0.003). Data are summarized in table 1.

	All cases	RD without macula involvement	RD with macula involvement	RD with macula involvement in the superior side	RD with macula involvement in the inferior side
Number of cases	97	62	35	24	11
Males/Females	64 33	42 20	22 13	17 7	5 6
Age	60.2 ± 8.4	60.7 ± 8.2	59.2 ± 8.4	60.3 ± 8.7	56.7 ± 7.3
Axial length measured by IOLmaster	25.22 ± 1.62	25.02 ± 1.64	25.55 ± 1.55	25.37 ± 1.67	25.95 ± 1.13
Axial length measured by A-scan	24.96 ± 1.60	24.76 ± 1.63	25.31 ± 1.47	25.14 ± 1.60	25.68 ± 1.05
Preoperative predictive refractive value measured by IOLmaster	-2.17 ± 2.19	-1.95 ± 2.11	-2.57 ± 2.27	-2.33 ± 2.30	-3.09 ± 2.10
Preoperative predictive refractive value measured by A-scan	-1.86 ± 2.27	-1.59 ± 2.20	-2.34 ± 2.27	-2.18 ± 2.32	-2.68 ± 2.26
Postoperative refractive value	-2.91 ± 2.72	-2.5 ± 2.47	-3.65 ± 2.98	-3.41 ± 3.17	-4.18 ± 2.44
Refractive error (IOLmaster)	-0.74 ± 0.96	-0.55 ± 0.77	-1.09 ± 0.64	-1.08 ± 1.32	-1.10 ± 0.64
Refractive error (A-scan)	-1.06 ± 0.97	-0.91 ± 0.78	-1.32 ± 1.19	-1.23 ± 1.39	-1.50 ± 0.51

Table 1: *Full description of our data. Data are presented as mean±standard deviation.*

Predicted refraction after cataract surgery is currently estimated by partial coherence laser interferometry and ultrasound A-scan biometry. IOL master® is a non-contact method, measured back to the retinal pigment epithelium layer, that uses a fixation beam that assists in obtaining measurements along the visual axis. However, the axial length when measured by A-scan is obtained via the signal of the internal limiting membrane. Compared to acoustic biometry, optical biometry has been reported to be more accurate in cataract eyes [6]. However, research on the estimation of intraocular lens power after vitrectomy in RD patients is lacking.

A previous study has reported on the efficacy of IOL master® in eyes of RD patients with macula involvement after phacovitrectomy. However, the same report also highlighted that combined phacovitrectomy in RD is associated with a small biometric error that is within the tolerable range in most cases [7]. Conversely, another report suggested that significant underestimation of axial length measurements occurs when using the IOL master® in these cases, which can affect IOL power selection when compared to immersion A-scan [8]. If the retina is detached, measures of the axial length with IOL master® may not be affected because the axial length is measured back to the retinal pigment epithelium layer. However, one may speculate that the axial length measured by A-scan may result in shorter estimates because the retina is detached.

In our study, we identified myopic shifts in the eyes of RD patients when measurements were performed both using IOL master® and A-scan. This was particularly evident in the patients with macula involvement. One may hypothesize that the refractive error identified in RD with macula involvement may derive from the fact that the detached retina interferes with light reflectivity during optical biometry, resulting in signals associated with the detached retina rather than with the RPE. Furthermore, patients with RD involving the macula may have poor fixation, which interferes with the alignment of the scan. Indeed, IOL master® relies on optical alignment methods in which the patient fixates on a light spot, thus ensuring better alignment of the measurement axis with the visual axis when compared to A-scan [9]. In the case of A-scan, myopic shifts may result in overestimation of the axial length because the signal measured by A-scan may come from an area of the attached part of retina, which may display a better signal than that from the detached area.

In accordance with our initial prediction that the location of the RD may affect axial length measurements when using both A-scan and IOL master®, we found that refractive error in the cases of incipient RD of the inferior side was significantly higher than that of incipient RD of the superior side, when measured by both A-scan ($P = 0.003$) and IOL master ($P = 0.003$). Although we considered that the cases of incipient RD of the superior side might affect measurements with IOL master® more significantly than the cases of incipient RD of the inferior side, in the current study, refractive error in the cases of incipient RD of the inferior side was significantly higher than that of incipient RD of the superior side. We considered that the axial length might not be measured by both A-scan and IOL master® in cases with bullous RD of the superior side that affected the measurement of axial length. Conversely, the axial length in the almost cases of RD in the inferior side might be measured by A-scan and IOL master. Further studies are required to assess the kind of cases in which axial length cannot be measured by A-scan and IOL master.

In our study, myopic shifts were identified in the eyes of RD patients even without macula involvement both for IOL master® and A-scan. These findings are in line with previous studies reporting myopic shifts in patients with attached retina after vitrectomy when using IOL maser® and A-scan [10-12]. Kovacs., et al. suggested that myopic shift results from underestimation of the axial length due to a thicker macula when using A-scan ultrasonography in ERM cases [10]. In contrast, Manvikar., *et al.* [11] reported that there is no tendency towards myopic shift in IOL power estimation using IOL Master®. Falkner-Radler., *et al*. [12] reported that there was myopic shift when combined phacovitrectomy was performed even for IOL power calculation using IOL Master®.

Previous studies have suggested that complete gas fill after phacovitrectomy with gas tamponade may induce an anterior displacement of the IOL resulting in myopic shift [12-14]. In this study, vitrectomy with gas tamponade was used for treating RD, which may have contributed to the myopic shift observed, irrespective of the method used for obtaining the measurements. Studies have also reported that replacement of the vitreous gel with the aqueous gel after vitrectomy results in a slight decrease in the refractive value and thus, a myopic shift [15-17]. Theoretically, the myopic shit in vitrectomized eyes can be approximately -0.5 D [16]. This value matches the refractive error of -0.55 D we found for RD eyes without involvement of the macula when using IOL master®. Although not significant, we observed a trend of the refractive error measured by A-scan to be higher than that measured by IOL master®. Considering that A-scan generally detects an area of 0.3 mm^2, which is larger than the area detected in optic biometry measurements (0.05 mm^2) [18], A-scan may in fact measure a different section of the macula in poor fixation cases even if the macula is not involved. This may result in the higher myopic shift obtained by using A-scan when compared with optic biometry in the eyes of RD patients without macula involvement.

The current study has several limitations we should acknowledge. Studies of IOL positioning reported that during the first postoperative week, IOL moves slightly forward, which is then neutralized by a slight backward movement within 3 months of implantation [19]. The follow-up period of our study was > 1 month, however if the follow-up period was longer, perhaps the refractive error would be lower. Further studies with longer follow-up periods may help to clarify this aspect. Moreover, an axial preoperative error in axial length measurement of 0.3 mm results in a 0.75 D difference in IOL power calculation which is clinically significant [20]. Measurements of axial length during post-operation would be needed to more precisely evaluate the estimation of predicted refraction. Previous studies have suggested refractive error is due to variations in the K-value [12]. However, we did not perform comparisons of the K-value before and after vitrectomy. This is an aspect future studies should bear in mind.

Conclusions

Predictive error is higher when measured with A-scan than with IOL master in cases where phacovitrectomy was performed for RRD, despite macula involvement. Predictive refraction error is particularly higher in patients with RD with macula involvement when measured both with A-scan or IOL master.

Acknowledgments

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Conflicts of Interest

The authors declare no conflicts of interest.

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Volume 10 Issue 1 January 2019