



Comparison between refractive outcomes between macula-on and macula-off retinal detachments after phaco-vitrectomy

Kang Yeun Pak^{1,2} · Keun Heung Park^{2,3} · Sung Who Park^{2,3} · Ik Soo Byon^{2,4} · Ji Eun Lee^{2,3}

Received: 28 May 2018 / Accepted: 12 March 2019 / Published online: 20 April 2019
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Abstract

Purpose To evaluate axial length (AL) measurements and refractive outcomes in vitrectomy combined with cataract operation for rhegmatogenous retinal detachment (RRD) with wholly detached macula.

Study design Retrospective, consecutive, comparative, clinical study.

Methods We reviewed the data of patients treated by vitrectomy combined with cataract operation for RRD. The group “Attach” (n=31) consisted of eyes in which retina was not detached within 1.5 disc diameters from the foveal center, and the group “Detach” (n=33) consisted of eyes in which that area was detached entirely. Only those eyes in the group “Detach”, only the eyes (n=20) which AL were measured similar to those fellow eyes were compared to the group “Attach” (n=31). Refractive shift (RS) was defined as the average of the difference between postoperative spherical equivalent (SE) and predicted SE.

Results AL was well measured by A-scan ultrasonography (A-scan) in all 31 eyes of the group “Attach” and their RS was -0.57 diopters (D). AL was measured by A-scan similar to the fellow eye in 20 of 33 eyes (60.6%) of the group “Detach”, and the RS was -0.09 D. The AL difference as much as central subfield macular thickness (about 300 μ m) can make this difference of RS (0.48 D, $P=0.025$)

Conclusion When AL can be measured by A-scan similar to its fellow eye in RRD with wholly detached macula, RS would be smaller than that of the wholly attached macula after phacovitrectomy. It assumed that AL was measured from the RPE under the detached macula in RRD with wholly detached macula.

Keywords Axial length · Partial coherence interferometry · Rhegmatogenous retinal detachment · Ultrasonography · Refractive outcomes

Introduction

The combined phacoemulsification/pars plana vitrectomy procedure is gaining popularity because it avoids the need for two separate surgeries and maximizes the surgeon’s view of the peripheral retina, especially in elderly patients [1]. When axial length (AL) is measured to determine a suitable intraocular lens (IOL) in rhegmatogenous retinal detachment (RRD), unexpected postoperative refractive errors (RE) can result.

Partial coherence interferometry (PCI) and A-scan ultrasonography (A-scan) are commonly used to measure AL. PCI is known to detect the distance from corneal surface to retinal pigment epithelium (RPE), while A-scan measures the distance from corneal surface to internal limiting membrane (ILM). Although measurements of AL by PCI are known to be more accurate and simpler than by A-scan [2, 3], the latter is

Corresponding author: Sung Who Park

✉ Sung Who Park
oph97@naver.com

- 1 Department of Ophthalmology, Haeundae Paik Hospital, Inje University, Busan, Korea
- 2 Department of Ophthalmology, School of Medicine, Pusan National University, Busan, South Korea
- 3 Medical Research Institute, Pusan National University Hospital, Ami dong 1-10, Seo-gu, Busan, South Korea
- 4 Research Institute for Convergence of Biomedical Science and Technology, Pusan National University Yangsan Hospital, Yangsan, South Korea

the only practical option in cases of corneal opacity, vitreous opacity, or macular detachment.

In RRD with macular attachment, AL can be measured readily and consistently by PCI or A-scan, with postoperative RE tends to be more myopic than target refraction [4, 5]. In contrast, measuring AL in eyes with a macula-off RRD is more challenging and data are insufficient for determining IOL power [4].

The purpose of the current study was to compare refractive outcomes according to macular status in RRD, and presume the way to measurement of AL in RRD with detached macula.

Materials and methods

Inclusions & exclusions

We retrospectively reviewed the medical records of consecutive patients who underwent pars plana vitrectomy and simultaneous cataract surgery for RRD from January 2008 to May 2014 and had been followed up for three months or more. The patients were divided into two groups—“Attach” and “Detach”. “Attach” was defined as eyes in which the area within 1.5 disc diameters (DD) from the foveal center was not detached, and “Detach” was defined as eyes where the area was entirely detached (Fig. 1). Eyes with partial detachment of the area were excluded. Detachment area was evaluated using preoperative funduscopy examination. Optical coherence tomography (OCT; Cirrus OCT, Carl Zeiss Meditec) images were used to verify funduscopy findings.

We excluded patients who had a history of intraocular surgery combined with scleral buckling, use of silicone oil tamponade, or needed additional surgery. Eyes were excluded if any of the following were present: thick vitreous hemorrhage that interfered with the preoperative detachment assessment, posterior capsule rupture, choroidal detachment



Fig. 1 Inclusion criteria of the groups “Attach” and “Detach”. (a) The group “Attach” included eyes with no detached macula within 1.5 disc diameters (DD) from the foveal center (white ring). (b) The group “Detach” included eyes with an entirely detached macula within 1.5 DD from the foveal center (white ring)

or zonular dialysis. The OCT images collected 3 months following surgery were reviewed and eyes with an epiretinal membrane (ERM) or cystoid macular edema (CME) were also excluded. The institutional review board of Pusan National University Hospital approved the study protocol, and the protocol complied with the tenets of the Declaration of Helsinki.

Surgical methods

Cataract surgery was performed with a superior clear corneal incision. After phacoemulsification and IOL implantation in the capsular bag, pars plana vitrectomy was performed using the Constellation/Accurus system (Alcon Laboratories, Inc.), a sutureless 23- or 25-gauge vitrectomy system, by four surgeons.

Data collection

The following data were collected: age, sex, pre- and postoperative intraocular pressure (IOP), AL, corneal refractive power, range of retinal detachment, and type of IOL. IOP was analyzed based on measurement with a noncontact tonometer preoperatively and at three months postoperatively. AL was measured, from 2011, by both A-scan (Aviso®, Quantel Medical), and by PCI (IOL master®, Carl Zeiss); prior to 2011, AL was measured by A-scan only. Measurements were performed by PCI considering the signal-to-noise ratio (SNR), which reflects the quality and reliability of PCI measurements of AL. Four sets or more were measured for each eye by A-scan; each set consisted of 10 measurements and its mean value was taken as its set value. Among the four set values, the longest set value was determined as its AL with A-scan. Measurement failure was defined when SNR was <1.0 in PCI, or when A-scan could not obtain four set values. An AL measurement was defined as a success if the AL was similar to the fellow eye, taking retinal detachment height and refractive error differences into account.

Predicted Spherical equivalent (SE) was calculated using the Sanders–Retzlaff–Kraff/Theoretical (SRK-T) formula, a constant of IOL, and corneal refractive power using the built-in software in A scan (AVISOTM, Quantel medical). Postoperative (3 months) SE was measured by automatic refractor keratometry and confirmed by subjective refractive vision test. Refractive shift (RS) was defined as average of the difference between postoperative and predicted SE.

End points & statistical analyses

The measurement success rate was compared between the two groups (n=31, n=33). The RS was compared between two groups (n=31, n=20) only in cases that AL had been

successfully measured by A-scan. To find factors to affect the successful measurement by A-scan in RRD, IOP, AL of the fellow eye, and range of the RRD were compared between eyes that had failed ($n=13$) and with successful AL measurements ($n=20$).

All statistical analyses were performed using SPSS for Windows 21.0 (SPSS Inc.). Differences between the two groups were assessed using either Mann–Whitney U-test (continuous factors) or Fisher’s exact test (categorical factors). The agreement between predicted and postoperative SE was analyzed using Spearman’s rank correlation coefficient. P -values <0.05 were considered statistically significant.

Results

Success rate of AL measurements

AL was successfully measured using A-scan in all 31 eyes of the group “Attach”. PCI detected AL in 19 (86.4%) of 22 eyes except three (13.6%) eye that had vitreous haze. In the group “Detach”, AL was successfully measured in 20 of 33 eyes (60.6%) using A-scan. AL could not be measured by PCI in any cases (0%) of the group “Detach”. The success rate of measurement was higher in the group “Attach” for both PCI ($p < 0.001$) and A-scan ($p < 0.001$).

In the group “Detach”, there were no significant differences between eyes with failed and successful AL measurements for any parameter examined ($p = 0.301$ – 0.758 , Table 1).

Eyes in the group “Detach” with failed axial length measurements

Fellow eye AL (measured using A-scan) was used to calculate predicted SE for the 13 eyes in the group “Detach” that had failed A-scan AL measurements. Predicted SE was

-0.83 ± 0.88 D, postoperative SE was -1.46 ± 1.88 D, and RS was -0.63 ± 2.11 D.

Comparison of RS between “Detach” and “Attach” groups

The RS was compared between the two groups only in cases that AL had been successfully measured by A-scan (20 eyes in the group “Detach,” 31 eyes in the group “Attach”). Baseline characteristics of the two groups are described in Table 2. There was no significant difference in age, sex, IOP change, AL, or type of IOL between the groups. There was a significant difference in preoperative IOP, postoperative IOP, IOP of the fellow eye, and range of detachment.

In the group “Attach”, the predicted SE was -0.36 ± 0.75 D, postoperative SE was -0.92 ± 1.14 D, RS was -0.57 ± 0.79 D, and absolute RS was 0.76 ± 0.41 D was (Table 3). In the group “Detach”, predicted SE was -0.63 ± 0.72 D, postoperative SE was -0.72 ± 0.99 D, RS was -0.09 ± 0.52 D and absolute RS was 0.41 ± 0.33 D. There was no significant difference between the groups in regard to predicted ($p = 0.123$) and postoperative SE ($p = 0.474$). RS for the group “Attach” was higher than that for the group “Detach” ($p = 0.025$). Absolute RS for the group “Attach” was higher than that for the group “Detach” ($p = 0.010$). Correlation coefficients between predicted and postoperative SE were 0.630 ($p < 0.001$) and 0.673 ($p < 0.001$) in the groups “Attach” and “Detach”, respectively (Fig. 2).

Discussion

It is important to accurately measure the biometric values including AL, corneal refractive power, and anterior chamber depth when predicting postoperative SE. Among these, AL is a key factor in predicting postoperative SE [6]. For many years, A-scan has been the only method available for measurement of AL, but PCI has recently gained popularity due to its accuracy and convenience [7–9]. However, A-scan remains a useful method because, in some cases, including RRD AL cannot be measured by PCI.

There are many reports on the prediction of postoperative SE and determination of IOL power when performing simultaneous vitrectomy and cataract surgery. Previous studies based on A-scan show that myopic shift was noticed after combined surgery and the reason of myopic shift might be anterior shift of IOL induced [10, 11]. A prospective study using A-scan and a recent retrospective study based on PCI show that RS was close to zero in cases other than RRD and similar to the values determined for cataract surgery alone [5, 12]

Table 1 Comparison of baseline parameters between measured and unmeasured eyes in the group “Detach”

	Measured	Unmeasured	P -value
Age (Years)	56.8 ± 7.2	56.8 ± 6.5	0.438
Pre-operative VA (LogMAR)	1.40 ± 0.45	1.12 ± 0.56	0.493
Post-operative VA (LogMAR)	0.57 ± 0.27	0.20 ± 0.12	0.301
Pre-operative IOP (mmHg)	11.6 ± 2.6	11.7 ± 5.0	0.482
AL of fellow eye (mm)	25.00 ± 1.59	24.85 ± 1.31	0.438
Range of retinal detachment (Hours)	9.4 ± 3.2	6.46 ± 3.36	0.758

Data are presented as mean \pm standard deviation

VA = visual acuity, IOP = intraocular pressure, AL = axial length

Table 2 Baseline characteristics of the groups “Attach” and “Detach”

	“Attach”	“Detach”	P-value
Number of eyes (N)	31	33	
Measurement failure (N)	0	13	<0.001
Measurement success (N)	31	20	<0.001
Male/female (N)	18/13	16/4	0.135
Age (years)	58.4±7.9	56.8±7.2	0.271
AL (mm) [range]	24.58±1.33 [21.56-26.89]	25.08±1.54 [23.01-29.63]	0.475
Fellow eye AL (mm) [range]	24.61±1.34 [21.39-27.34]	25.00±1.59 [22.60-29.23]	0.562
Preoperative Corneal refractive power	42.59±1.53	42.42±1.14	0.790
Preoperative Corneal refractive power	42.21±1.95(p*=0.157)	42.34±1.34(p*=0.55)	0.900
Preoperative IOP (mmHg)	13.8±2.3	11.6±2.6	0.002
Postoperative IOP (mmHg)	14.9±3.0	12.4±2.3	0.002
IOP change (mmHg)	1.1±2.5	0.9±2.6	0.876
Fellow eye IOP (mmHg)	15.1±2.4	13.3±2.6	0.029
Range of retinal detachment (hours)	4.7±2.1	9.4±3.2	0.010
Type of Intraocular lens (N)			0.102
Hoya iSert® 251	16	9	
Alcon Acrysof® IQ	6	7	
Rayner Superflex® 620H	3	4	
AMO Tecnis® ZA9003	6	0	

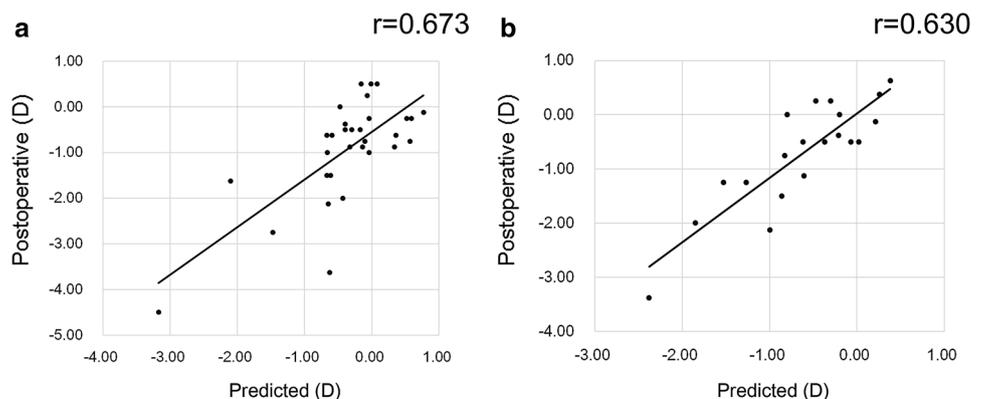
Data are presented as mean ± standard deviation
 IOP = intraocular pressure, AL = axial length
 Asterisks indicate compared to preoperative value

Table 3 Comparison of refractive outcomes between groups “Attach” and “Detach”

	“Attach”	“Detach”	P-value
Predictive spherical equivalent (D)	-0.36±0.78	-0.63±0.71	0.123
Postoperative spherical equivalent (D)	-0.92±1.14	-0.72±0.99	0.474
Refractive shift (D)	-0.57±0.79	-0.09±0.52	0.025
Absolute refractive shift (D)	0.76±0.41	0.41±0.33	0.010

Data are presented as mean ± standard deviation
 D = diopters

Fig. 2 Correlation analysis between pre- and postoperative refractive error in the groups “Attach” (a) and “Detach” (b). Predicted, predicted spherical equivalent; Postoperative, postoperative spherical equivalent; D, diopters



In cases with RRD not involving the macula, RS was found to be -0.43 D [5]. On the other hand, in RRD involving the macula, previous reports reveal the difficulty and inaccuracy of AL measurements [13, 14], as no reliable data were obtained for RS.

In RRD, AL measurement by A-scan can fall into one of three categories (Fig. 3). When macula is partially detached, A-scan can detect the surface of the attached macula (internal limiting membrane [ILM], Fig. 3a) or the surface of the RPE, due to ignorance of detached macula (Figure 3b). When A-scan detected the surface of the detached macula (ILM), the measured AL was shorter and was judged to have failed (Fig. 3c). Although differences among the three ways would have a major impact on RS, no studies have considered these situations to date. The present study aimed to compare two ways; detecting the surface of the attached macula (Fig. 3a, the attached group) and detecting the surface of the RPE (Fig. 3b, the detached group). We excluded cases of RRD with partially detached macula in the 1.5 DD areas, in which it was hard to differentiate two ways (Fig. 3a, b).

In the current study, RS for the group “Attach” was -0.57 ± 0.79 D, similar to the value reported by Cho et al. (PE = -0.43 D in fovea-sparing RRD) [5]. On the other hand, Rahman et al. report a value for RS of -0.42 D in fovea-involved RRD, significantly different from the value found in the current study (RS = -0.09 D) [4]. This disparity is explained in Figure 3: Rahman et al. included eyes measured by two ways including partial detached macula (Figure 3a, b), while the current study included eyes measured by one way only, wholly detached macula (Figure 3b) [4].

Cho et al. report that RS is related to changes in IOP following vitrectomy [5]. In the current results, although there were significant differences in pre- and postoperative IOP, there were no significant different IOP changes between

groups. Interestingly, IOP values were significantly different not only in the treated eyes but also in the fellow eyes. The group “Detach” had a wider detached area and a lower IOP than the group “Attach”. We assume that lower IOP might have an impact on the progression of retinal detachment. Further study will be performed in the near future to elucidate these correlations.

There are several reports about axial length changes after vitrectomy for RRD. Cho et al. insist that AL would increase following RRD repair surgery [5]. They hypothesize that because the IOP is low in detached state, the measured AL appears to be shorter than the actual one with normal IOP. After retinal reattachment and subsequent IOP normalization, the AL would theoretically be longer than before surgery. However, they could not prove it by measuring postoperative axial length. Additionally, Rahman et al. measured pre- and postoperative AL in 40 of 96 patients with PCI. Axial length was not significantly different before and after surgery [4]. To the best of our knowledge, no prior studies have reliably shown that AL ultrasonography measurements change after vitrectomy for RRD repair.

The values for RS were -0.57 and -0.09 D in the groups “Attach” and “Detach”, respectively, a difference of 0.48 D. AL appeared to increase by as much as macular thickness in the group “Detach” (Fig. 3b). Central subfield macular thickness was roughly 0.3 mm [300 μm , cf], $264.9 \pm 49.7 \mu\text{m}$ in the detached group], which makes a difference in IOL power of about 0.75 D (based on the SRK/T formula: IOL power = A constant $- 2.5 \times \text{AL} - 0.9 \times \text{keratometry}$). An IOL power of 0.75 D is in accord with about 0.5 D of SE. Consequently, we assumed that overestimation of AL by approximately 300 μm due to exclusion of macular thickness would account for a reduction in RS of about 0.5 D in the group “Detach”.

In the group “Detach”, AL was not reliably determined by PCI in any of the 19 eyes; this means that PCI did not

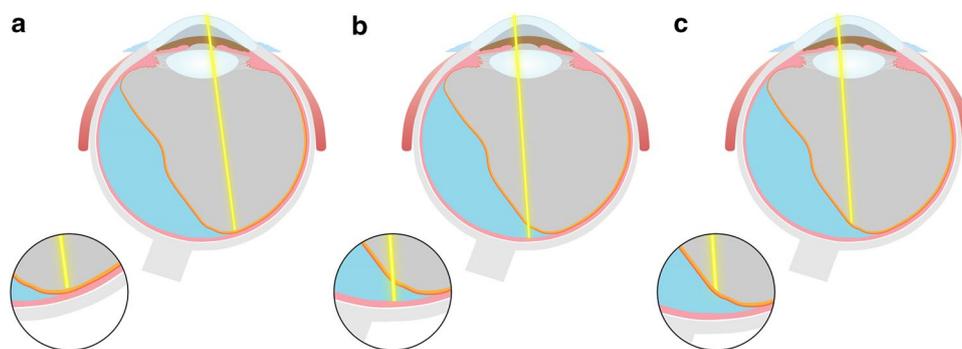


Fig. 3 Three ways of axial length measurements in rhegmatogenous retinal detachment (RRD). (a) Axial length as measured by A-scan ultrasonography (A-scan) and partial coherence interferometry (PCI) at the attached macula. (b) A-scan can detect the surface of the retinal pigment epithelium due to passing the detached macula, but PCI may not determine the axial length in this manner. (c) When A-scan

or PCI was reflected at the surface of the detached macula, the measured AL was shorter than that of the fellow eye and measurement was adjudged to have failed. Measured axial length in (b) would be longer as much as central subfield macular thickness (300 μm) than in (a). An axial length of 300 μm is correlated with 0.5 D of mean error

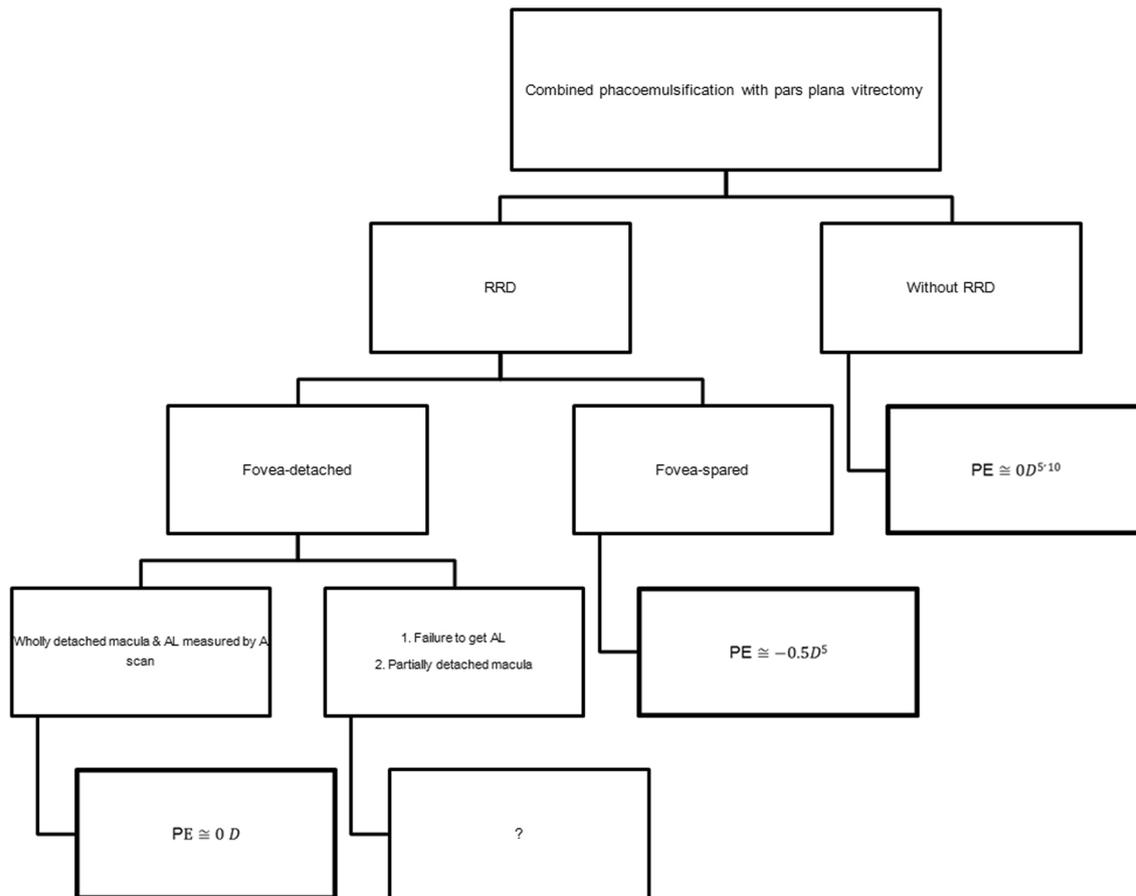


Fig. 4 Recommendations for performing a suitable intraocular lens power calculation for a combined phacoemulsification/pars plana vitrectomy procedure. All suggestions are based on the findings of

previous reports and the current study. RRD, rhegmatogenous retinal detachment; AL, axial length; D, diopters; PE, prediction error

detect RPE under the detached macula (Fig. 3b), i.e., that it measured only the attached maculae (Figure 3a). When AL could be measured by PCI, the RS value would be approximately 0.48 D after surgery for RRD repair [5]. On the other hand, A-scan was able to measure both the attached maculae (Fig. 3a) and the RPE under the detached macula (Fig. 3b). IOL power calculations using A-scan in RRD should be based on whether AL was measured at the attachment area (Fig. 3a) or under the detached macula (Fig. 3b). In cases when RRD involved the whole macula (i.e., the group “Detach”) and measurement was by A-scan, the PE values were close to zero.

Kim et al. show that AL measurement is likely to fail, in RRD with large detached angle and high heights of macula [15]. Because, unlike Kim et al. we excluded RRD with partially detached macula, detached angle and heights of macula could not be measured in most cases. There was no significant difference between failure and success of measurements in the group “Detach”

Based on the current study, we offer suggestions on determining a suitable IOL power (Fig. 4).

Prediction error in combined operation

- 1) If there is fovea-spared RRD, RS would be about -0.5D (Cho et al. [5], current study).
- 2) There is no exact data relating to RS in a partially detached macula.
- 3) Whenever the AL can be measured by-A scan similar to its fellow eye in RRD of wholly detached macula, RS would be about zero D (current study).

The present study has certain limitations. First, postoperative AL, potentially a key factor in proving our theory, was not measured due to the retrospective nature of the study. Measuring AL with ultrasonography can cause patients distress. This is particularly true in patients with pseudophakia because ultrasound AL measurements are much more

difficult to obtain in eyes with a lens implant than in eyes with natural crystalline lens. We did attempt postoperative ultrasound AL measurements in some patients. Unfortunately, this was difficult in most patients and some patients refused the test. Therefore, we were unable to collect meaningful data. Second, there was a significant difference in the range of retinal detachment between the groups; this range difference is unavoidable for definition of the groups. Because of variations in the types of IOL inserted, there is a potential bias based on IOL per se. However, there were no significant differences between the types of IOL used in the two groups. Lastly, predicted SE was calculated using only the SRK-T formula. We had also calculated predicted SE using the Haigis formula, but the correlation coefficient between predicted and postoperative SE was -0.119 , which was not statistically significant ($p=0.627$). Our Haigis formula calculations utilized anterior chamber depth (ACD) that had been measured using A-scan. Therefore, we postulated that using contact A-scan ACD measurements in the Haigis formula are inappropriate. To the best of our knowledge, there are no prior reports of using contact A-scan measurements in the Haigis formula.

In Conclusion, PCI appears to be able to measure AL reliably in RRD, but only at the attached macula. On the other hand, A-scan can measure AL at both areas; the detached macula and the attached macula (Fig. 3). When AL can be measured by A-scan similar to its fellow eye in RRD with wholly detached macula, RS would be smaller than that of the wholly attached macula after phacovitrectomy. It is assumed that in RRD with wholly detached macula, AL was measured from RPE under the detached macula.

Conflicts of interest K. Y. Pak, None; K. H. Park, None; S. W. Park, None; I. S. Byon, None; J. E. Lee, None.

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