The differences of axial length measurements between A-scan ultrasound and partial coherence interferometry (IOL Master) in macula-off retinal detachment.

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Directed by Professor Eung Kweon Kim

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ABSTRACT

The differences of axial length measurements between
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The purpose of this study is to compare the axial length measurement by A-scan ultrasound and partial coherence interferometery (IOL Master) in eyes with macula-off retinal detachment.

This study is a retrospective medical record review of 46 patients who had macula-off retinal detachment with contralateral normal eye from August 1, 2009, to August 31, 2011. The axial length measured by A-scan ultrasound and IOL Master was compared with paired *t* test. Correlation between 2 methods was assessed by Pearson correlation coefficient and agreement between 2 methods was analyzed by Bland-Altman plot.

The mean axial length was 25.07 ± 1.85 mm by A-scan ultrasound and 25.14 ± 1.87 mm by IOL Master in normal eyes group and 24.91 ± 1.80 mm by A-scan ultrasound and 24.03 ± 2.00 mm by IOL Master in detached eyes group, respectively. The mean axial length by A-scan ultrasound was shorter in normal eyes group but longer in the detached eyes group than that by IOL Master. The axial length measured by 2 methods was strongly correlated in normal and detached eyes groups. There were close ranges of 95% limits of agreement in normal eyes group and wide ranges of 95% limits of agreement in the detached eyes group in Bland-Altman plot.

The intraocular lens (IOL) power in normal eyes group was 16.96 ± 5.25 D by A-scan ultrasound and 17.22 ± 5.33 D by IOL Master and the difference between 2 methods was not significantly different. However, the IOL power in detached eye groups was 17.34 ± 4.81 D by A-scan ultrasound and 19.90 ± 5.27 D by IOL Master and the difference of IOL power was clinically significantly different.

The axial length by IOL Master was shorter and IOL power by IOL Master was stronger than those measured by A-scan ultrasound in macula-off retinal detachment. IOL Master would detect the detached retina rather than the retinal pigment epithelium. This implies that axial length and IOL power calculated by A-scan would be more appropriate than those by IOL Master.

Key words : axial length, A-scan, partial coherence interferometry, IOL Master, macula-off retinal detachment

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I. INTRODUCTION

Rhegmatogenous retinal detachments (RRD) involving macula significantly affect visual acuities and prompt surgical interventions are essential for maintaining visual acuities. There are many surgical techniques of treatment for RRD including scleral buckling, pars plana vitrectomy, pneumatic retinopexy, and combination of these techniques. However, there is no definitive result that shows which procedure is better in previous studies.[1-3] As a result, the selection of surgical technique is determined by the surgeon's preference. One study showed an increasing trend in the use of part plana vitrectomy over scleral buckling because of the disadvantages including induced refractive error and tissue damage in scleral buckling and the improvements of vitrectomy instruments.[1]

Cataracts are often co-morbid with retinal detachment in the elderly population. After vitrectomy, cataracts could progress postoperatively and one study reported that the rate of cataract after vitrectomy was 75% over 10-year follow-up.[4] Cataract extraction surgery in vitrectomized eye could be difficult because of excessively mobile posterior capsule and decreased zonular support of the lens.[5] These difficulties of cataract surgery after vitrectomy made a concept of combined phacoemulsification and vitrectomy. Many studies revealed that combined surgery was safe and effective in vitreoretinal diseases including retinal detachment.[6-10]

The measurement of the axial length (AL) was the most important factor for selecting IOL power in cataract surgery.[11,12] A-scan ultrasound (US) was used for measuring the AL, traditionally. It had been known that A-scan US measures the AL from the corneal vertex to the vitreoretinal interface. The measured AL would be shorter than actual AL with wide deviations because of applanation techniques which compress the cornea.[13-16] Recently, non-contact partial coherent laser interferometry (IOL Master, Carl Zeiss Meditec, Jena, Germany) was also used by many ophthalmologists to calculate IOL power, preoperatively. IOL Master measured the AL from the tear film to the retinal pigment epithelium (RPE) with adjusting for normal retinal thickness in healthy eyes.[17] And result of the IOL Master were reported to show more accurate and reproducible with close ranges because of non-contact technique.[18,19] Some studies showed that IOL power calculation by the IOL Master was more emmetropic than that by the A-scan US biometry.[20,21]

In this study, we compared the AL measured by A-scan US and IOL Master in macula-off retinal detachment eyes with contralateral normal eyes. Our purpose of this study is to examine the hypothesis that the AL measured by A-scan US would be shorter than it by IOL Master because the A-scan US would detect the detached retina while IOL Master would detect RPE instead of detached retina.

II. MATERIALS AND METHODS

The retrospective medical records of 92 eyes of 46 patients with macula-off retinal detachment who underwent primary repair at Yonsei University Medical Center from August 1, 2009, to August 31, 2011 were reviewed. Inclusion criteria were patients who had macula-off retinal detachment in one eye without any ocular disease in the contralateral eye. Patient who had diabetic retinopathy, macular disease including age-related macular degeneration and epiretinal membrane, anisometropia, or previous ocular trauma were excluded from this study. The eyes were divided into 2 groups: detached eyes were enrolled in the detached eyes group (study group) and contralateral normal eyes were enrolled in the normal eyes group (control group). Information from the patients' medical record included age, gender, any medical problems such as diabetes mellitus and hypertension, uncorrected visual acuity (UCVA), best spectacle-corrected visual acuity (BSCVA), slit-lamp examination, tonometry, dilated funduscopy, autokeratometery, and pachymetry. The axial length was measured by the IOL Master followed by the applanation A-scan US after a few minutes; the average of best 5 measurements was obtained. After the AL measurements, intraocular power was calculated with SRK/T formula. The A-constant was customized according to the IOL that was selected by the surgeon.

Visual acuities of all patients were converted to logarithm of the minimum angle of resolution (logMAR) for statistical comparison. For statistical analysis, counting fingers, hand movements, light perception, and no light perception visual acuities were assigned logMAR scores of 1.70, 2.00, 2.30, and 3.00, respectively.[22] Comparison of the AL measured by A-scan US and IOL Master was performed by a paired *t* test. Pearson correlation coefficient was used to evaluate relationship between 2 methods. Agreement between 2 quantitative measurements was analyzed with Bland-Altman plot with 95% limits of agreement lying within the 1.96 x standard deviation of the mean difference. This is known to be a standard method for comparing the quantitative measurements measured by 2 different devices.[23] Data analyses were performed by SPSS 18.0 for Windows (SPSS, Inc.) and statistical significance was considered P value less than 0.05.

III. RESULTS

Ninety-two eyes of 46 patients (23 men and 23 women) with an average age of 50 ± 21 years (range: 17 to 80 years) were enrolled in this study. The mean visual acuity (logMAR) and intraocular pressure (mmHg) were 0.09 ± 0.14 and 14.78 ± 3.29 in the normal eyes group and 1.39 ± 0.52 and 12.51 ± 3.65 in the detached eyes group, respectively. Visual acuity and IOP of the normal eyes group were statistically significantly better and higher than those of the detached eyes group (Table 1).

Table 1. Comparisons of visual acuity and intraocular pressure between normal eye group and detached eye group of 92 eyes of 46 patients

	Normal eye, Mean ± SD	**Detached eye, Mean ± SD**	***P-value***
VA (logMAR)	0.09 ± 0.14	1.39 ± 0.52	<0.001
IOP (mmHg)	14.78 ± 3.29	12.51 ± 3.65	0.002

VA = visual acuity; logMAR = logarithm of the minimum angle of resolution;
IOP = intraocular pressure

The mean AL measurements measured by the A-scan US and IOL Master were 25.07 ± 1.85 mm and 25.14 ± 1.87 mm in the normal eyes group and 24.91 ± 1.80 mm and 24.03 ± 2.00 mm in the detached eyes group, respectively. The AL measured by the 2 methods was statistically significantly different in both groups (Table 2). The AL measured by A-scan US was significantly shorter in the normal eyes group but longer in the detached eyes group than that measured by IOL Master (*P*<0.001).

Table 2. The axial length measurements by A-scan and IOL Master between normal eye group and detached eye group of 92 eyes of 46 patients				
	AL measured by A-scan (mm), Mean ± SD	**AL measured by IOL Master (mm), Mean ± SD**	**Difference of AL, A-scan minus IOL Master (mm), Mean ± SD**	***paired t* test of AL by two methods**
Normal eye	25.07 ± 1.85	25.14 ± 1.87	-0.08 ± 0.10	*P* <0.001
Detached eye	24.91 ± 1.80	24.03 ± 2.00	0.87 ± 1.23	*P* <0.001

AL = axial length

The correlation between 2 methods was very strong in the normal eyes group and moderately strong in detached eyes group, mathematically. Pearson correlation coefficient values were r=0.999 in the normal eyes group (P<0.001) and r=0.794 in the detached eyes group (P<0.001). The correlations between 2 methods were shown in Figure 1 and 2.

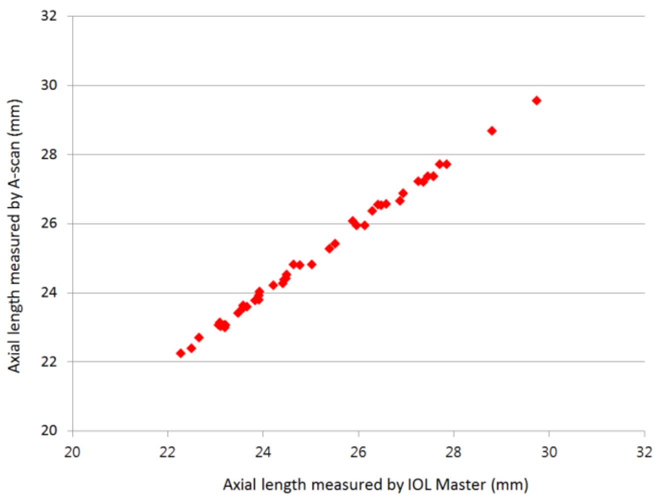


Figure 1. Scatterplot demonstrating correlation of axial length measured by A-scan and IOL Master in the normal eyes group.

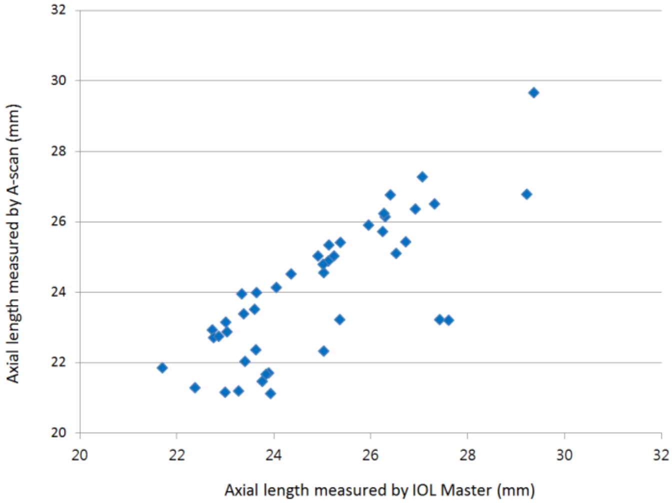


Figure 2. Scatterplot demonstrating correlation of axial length measured by A-scan and IOL Master in the detached eyes group.

Agreement test between two methods was performed by Bland-Altman plots with 95% limits of agreement (Figures 3 and 4). All points (100%) of the normal eyes group and 44/46 (95.7%) of the points in the detached eyes group were within 95% limits of agreement. The limits of agreement were -0.41 to 0.21 mm in the normal eyes group and -1.54 to 3.28 mm in the detached eyes group.

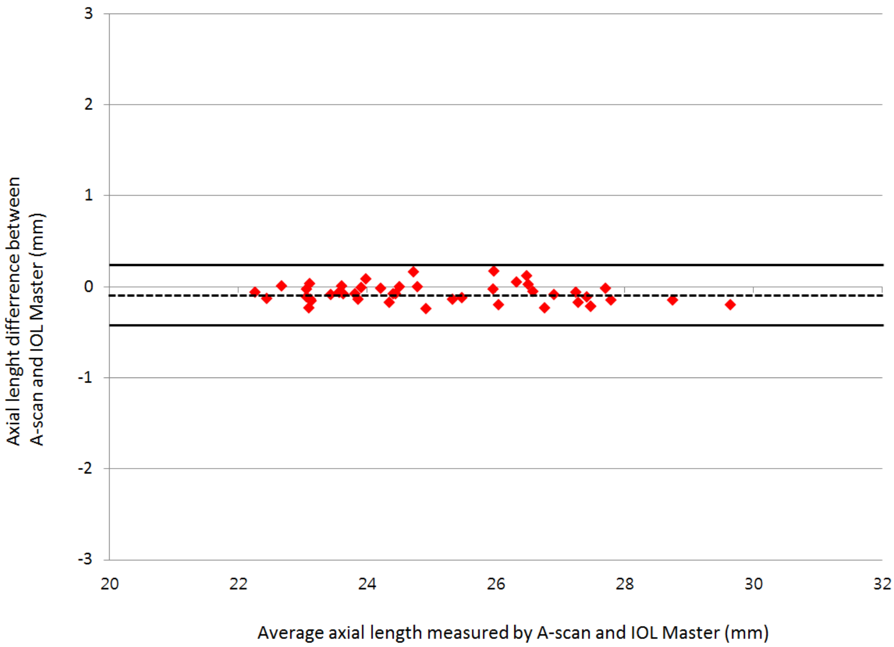


Figure 3. Bland-Altman plot shows interdevice difference plotted against mean axial length measured by A-scan and IOL Master in the normal eyes group. Dotted line means mean difference (-0.10 mm) and solid line means limit line of the 95% limits of agreement.

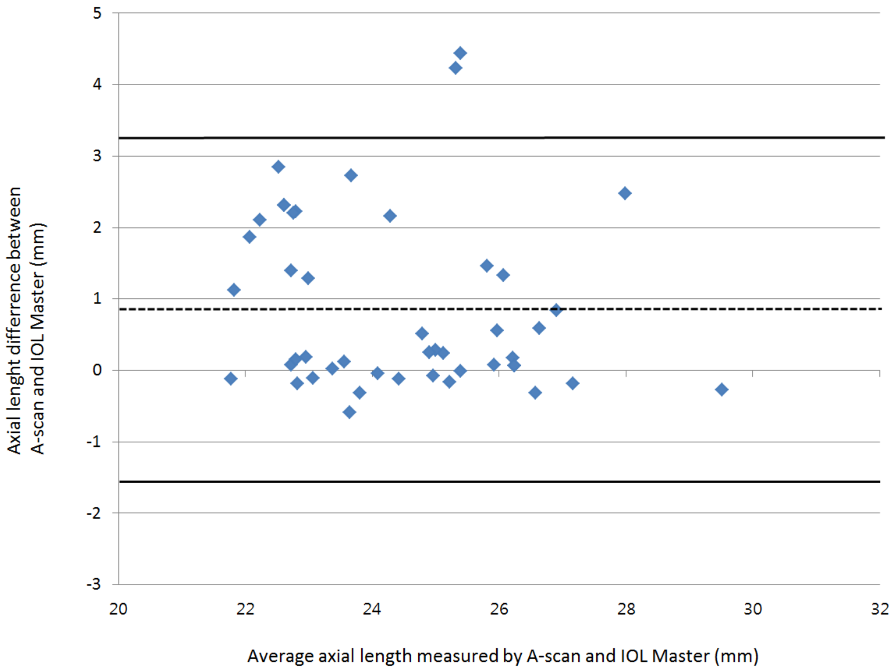


Figure 4. Bland-Altman plot shows interdevice difference plotted against mean axial length measured by A-scan and IOL Master in the detached eyes group. Dotted line means mean difference (0.87mm) and solid line means limit line of the 95% limits of agreement.

The IOL power calculated by A-scan US and IOL Master was 16.96 ± 5.25 D and 17.22 ± 5.33 D in the normal eyes group and 17.34 ± 4.81 D and 19.90 ± 5.27 D in the detached eyes group, respectively. The difference of the 2 methods (A-scan minus IOL Master) was -0.26 ± 1.87 D in the normal eyes group and -2.56 ± 3.91 D in the detached eyes group. The difference of IOL power between 2 methods was not different in normal eyes group (P=0.352) but clinically significantly different in detached eyes group (P<0.001).

Table 3. The intraocular lens (IOL) power calculated A-scan and IOL Master between normal eye group and detached eye group of 92 eyes of 46 patients

	IOL power measured by A-scan (D), Mean ± SD	**IOL power measured by IOL Master (D), Mean ± SD**	**Difference of IOL power, A-scan minus IOL Master (D), Mean ± SD**	***paired t* test of IOL power by two methods**
Normal eye	16.96 ± 5.25	17.22 ± 5.33	-0.26 ± 1.87	*P* =0.352
Detached eye	17.34 ± 4.81	19.90 ± 5.27	-2.56 ± 3.91	*P* <0.001

D = diopter

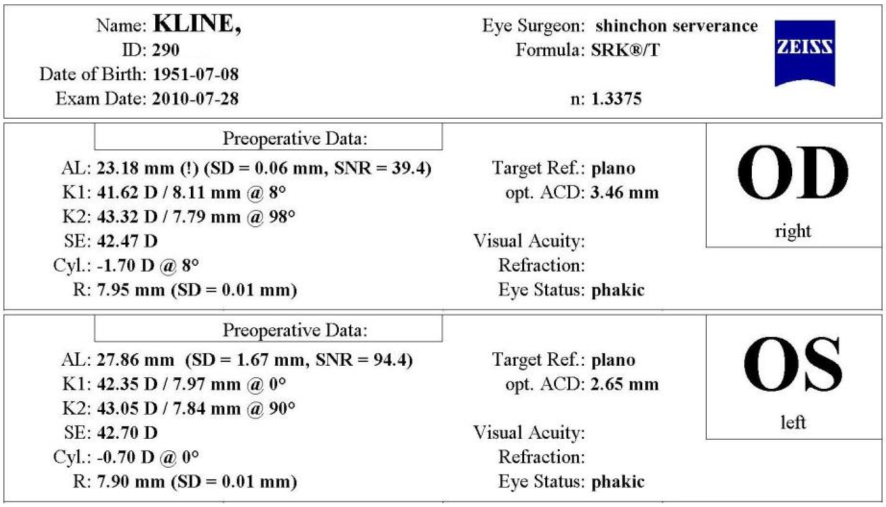
IV. DISCUSSION

Recently, many surgeons prefer pars plana vitrectomy than scleral bucking for repairing of RRD with the aid of advancement of the vitrectomy equipment and less manipulation.[1] Patients with eyes of the RRD already had cataracts especially in elderly patients. Combined phacoemulsification and vitrectomy could be preferred because of the advantages including shorter postoperative recovery time, good visualization during operation and postoperatively, and reduce medical coast of secondary cataract surgery.[6-10] Furthermore, cataract could progress after vitrectomy[4] and cataract surgery after vitrectomy increased the risk of posterior capsular rupture, zonulodiaylsis, and loss of lens material posteriorly.[24,25] And, some surgeons performed cataract extraction surgery with phacoemulsification before pars plana vitrectomy, when the surgical filed was impaired by the cataracts. There are many reports that combined phacoemulsification and vitrectomy is safe and effective in various vitreoretinal diseases.[6-10] But, few studies for measurements of AL and IOL power calculation in vitreoretinal disease were reported.

It was well known that the AL was the most powerful factor to predict accurate IOL power.[11,12] The axial length measured by A-scan US would be shorter, because technician would compress the cornea using applanation A-scan US probe. Additionally, A-scan US measured the AL from corneal vertex to vitreoretinal interface, but IOL Master measured the AL from tear film to retinal pigment epithelium.[7-9] Because of these differences between 2 methods, the AL measured

IOL Master despite adjusting for the difference between internal limiting membrane and RPE had a tend to longer AL than that by A-scan US.[12,26] One study showed that IOL power calculated by IOL Master in cataract patients was 0.17D more accurate than that by A-scan US for predicting the postoperative spherical equivalent.[20] In eyes of diabetic macular edema (DME), IOL power calculated by IOL Master was more accurate than that calculated by A-scan US, also.[21,27] The A-scan US would detect elevated internal limiting membrane, but IOL Master detect the reflection made by RPE layer in patients with DME. After treatment of DME with focal photocoagulation, the postoperative spherical equivalent was more accurate in IOL Master.[27]

In this study, we compared the AL measured by A-scan US and IOL Master in normal and detached eyes group. As we excluded anisometropia, we could presume that the AL between 2 groups would not be clinically significantly different. Actually, the AL between normal and detached eyes was not different in A-scan US measurements (P=0.678). Between 2 modalities to measure the AL, the AL measured by IOL Master was clinically significantly longer than that measured by A-scan US in normal eyes group as other studies already revealed. However, the AL of the IOL Master was clinically significantly shorter than that of the A-scan US in detached eyes group. IOL Master would detect the detached retina instead of the attached RPE layer. The partial coherent interferometery which used a mean group of refractive index could be reflected by irregular retinal structure, internal limiting membrane, or interface between retinal and subretinal fluids. And, detached eyes could not detect the fixating light of the IOL Master due to the low vision.[21] IOL Master could not detect the AL along the visual axis, consequentially inaccurate results could be made. However, A-scan US measured the AL along the optical axis which was independent of the patient's vision. If the A-scan US detects the detached retina, we could expect that AL measured by A-scan US would be at least similar (or shorter) than that by IOL Master in the detached eyes group. In this study, the AL measured by A-scan US was rather longer than that measured by IOL Master. One of our patients, there was a definite macula-off retinal detachment of the right eye in the B-scan ultrasound. The detached retina was detected in the middle of the globe in the B-scan. In the IOL Master, the AL of the right eye (23.18 mm), which was detached, was much shorter than that of the normal left eye (27.86 mm). IOL Master seemed to detect the centrally located detached retina (Figure 5).


Name: **KLINE,**
ID: **290**
Date of Birth: **1951-07-08**
Exam Date: **2010-07-28**
Eye Surgeon: **shinchon serverance**
Formula: **SRK®/T**
n: **1.3375**

Preoperative Data:
AL: **23.18 mm (!) (SD = 0.06 mm, SNR = 39.4)**
K1: **41.62 D / 8.11 mm @ 8°**
K2: **43.32 D / 7.79 mm @ 98°**
SE: **42.47 D**
Cyl.: **-1.70 D @ 8°**
R: **7.95 mm (SD = 0.01 mm)**
Target Ref.: **plano**
opt. ACD: **3.46 mm**
Visual Acuity:
Refraction:
Eye Status: **phakic**
OD
right

Preoperative Data:
AL: **27.86 mm (SD = 1.67 mm, SNR = 94.4)**
K1: **42.35 D / 7.97 mm @ 0°**
K2: **43.05 D / 7.84 mm @ 90°**
SE: **42.70 D**
Cyl.: **-0.70 D @ 0°**
R: **7.90 mm (SD = 0.01 mm)**
Target Ref.: **plano**
opt. ACD: **2.65 mm**
Visual Acuity:
Refraction:
Eye Status: **phakic**
OS
left

Figure 5. The axial length measured by IOL Master. The axial length of the patient

was 23.18 mm in the right eye which was detached and 27.86 mm in the left eye which was normal.

But, there was no definite retinal spike in the right eye which was detached in the A-scan US (Figure 6A). A-scan US only used single point of echoes reflected by ocular structures and could ignore the single retinal spike and detect the complex of choroid and sclera which had sustained high echoes spikes in detached eyes group. And A-scan US measured the AL from corneal vertex to retina-choroid-sclera complex in the normal eyes group (Figure 6B). Furthermore, the strength of echoes in A-scan US was influenced by size and shape of acoustic interfaces, the angle of sound beam incidence, absorption, scattering, and refraction.[29,30] The echoes of the detached retina could be reduced by things mentioned above. Small spikes between posterior capsule and choroid-scleral complex might be detached retinal spikes which was reduced (Figure 6A).

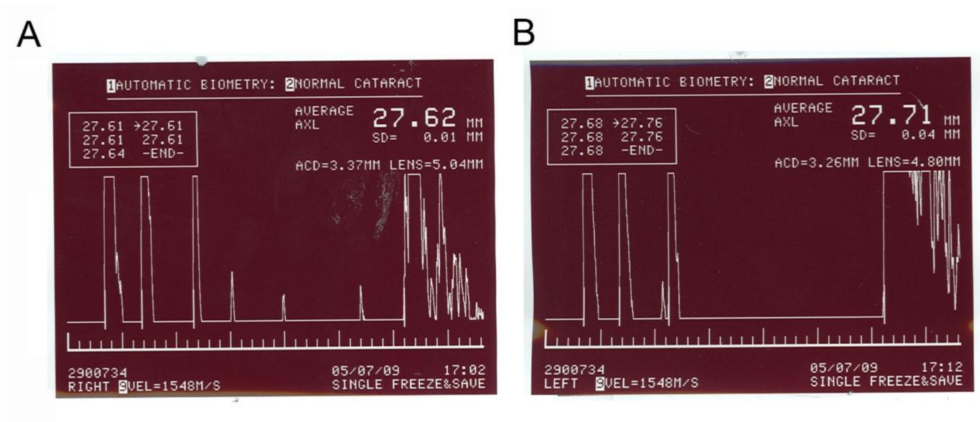


Figure 6. The A-scan ultrasound (US) of the patient who had the retinal detachment

in the right eye. A) A-scan US of the right eye which was detached. B) A-scan US of the left eye which was normal.

Although there was correlation between A-scan US and IOL Master in normal and detached eyes group, agreement analysis showed that the 95% limits of agreement spanned 0.62 mm in the normal eyes group and 4.82 mm in the detached eyes group. This implies the AL differences of between A-scan and IOL Master had close ranges in the normal eyes group but wide ranges in the detached eyes group. In our study, IOL power calculated by A-scan US and IOL Master was not different in normal eyes group (P=0.352). SRK/T formula used axial length and corneal power to calculate IOL power.[31,32] The difference of the AL by 2 methods was relatively small (0.08mm) and the difference of IOL power could be masqueraded by the difference of corneal power. However, IOL power by IOL Master was +2.56 D stronger with wide ranges than that by A-scan because of shorter AL measurements in IOL Master. It seemed better to select IOL power according to A-scan US instead of IOL Master in our study.

V. CONCLUSION

In conclusion, IOL Master would detect the detached retina instead of the RPE and this makes inaccurate AL measurements and IOL power calculations for the detached eyes. Therefore AL measurements and IOL power calculation in macula-off retinal detachment with IOL Master would be inappropriate. However, A-scan US would detect the choroid-scleral complex instead of the detached retina. In the patient who had retinal detachment, the AL and IOL power calculated by A-scan US would be better than that calculated by IOL Master.

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ABSTRACT(IN KOREAN)

황반을 포함한 망막박리 환자에서 A−scan과 IOL Master를 이용하여 측정한 안축장 길이의 차이

<지도교수 김응권>

연세대학교 대학원 의학과

강 의 천

본 연구는 황반을 포함한 망막박리 환자에서 A−scan과 IOL Master를 이용하여 측정한 안축장 길이의 차이를 비교하기 위해 진행되었다. 본 연구는 2009년 8월부터 2011년 8월까지 세브란스병원에 내원한 황반을 포함한 망막박리를 가진 환자 중에서 반대편 안구의 특별한 질환이 없는 사람 46명을 대상으로 진행되었다. A−scan과 IOL Master를 통해 측정된 안축장 길이는 대응 표본 T 검정을 통해 비교하였다. 두 가지 검사간의 상관관계는 Pearson 상관계수를 이용하여 비교하였고, 검사간의 일치도는 Bland−Altman plot을 이용하여 분석하였다.

안축장 길이의 평균은 정상안 군에서는 A−scan으로 측정할 경우 25.07 ± 1.85 mm이었으며, IOL Master로 측정할 경우는 25.14 ± 1.87 mm였다. 또한, 망막박리안 군에서는 A−scan으로 측정할 경우 24.91 ± 1.80 mm였으며, IOL Master로 측정할 경우 24.03 ± 2.00 mm였다. A−scan으로 측정된 안축장의 길이는 정상안 군에서는 IOL Master로 측정된 길이보다 짧았으나, 망막박리안 군에서는 IOL Master로 측정된 길이보다 길었다. 두 가지 방법으로 측정된 안축장의 길이는, 정상안 및 망막박리안 군 모두에서 강한 상관관계를 가졌다. Bland−Altman plot에서 95%의 일치구간은, 정상안 군에서는 좁았으나, 망막박리안 군에서는 넓었다.

인공수정체 도수의 경우 정상안 군에서는 A-scan으로 측정할 경우 16.96 ± 5.25 D이었으며, IOL Master로 측정할 경우 17.22 ± 5.33 D이었으며, 두 방법 간의 측정값의 차이는 없었다. 그러나, 망막박리안 군에서는 A-scan으로 측정할 경우 17.34 ± 4.81 D이었으며, IOL Master로 측정할 경우 9.90 ± 5.27 D이었고, 두 방법간에 차이가 있었다.

황반을 포함한 망막박리 환자의 안축장 길이는 IOL Master로 측정할 경우가, A-scan으로 측정한 경우보다 짧았으며, 인공수정체 도수의 경우는 IOL Master로 측정할 경우가 A-scan으로 측정한 경우보다 높은 인공수정체 도수 소견을 보였다. IOL Master가 망막색소상피를 탐지하기보다, 박리된 망막을 측정함으로 인해 발생한 결과로 생각된다. 이것은 망막박리안에서 안축장 길이 측정과 인공수정체 도수를 예측함에 있어, IOL Master는 부정확하다는 것을 암시한다고 할 수 있겠다.

핵심되는 말 : 안축장 길이, A-scan, IOL Master, 황반을 포함한 망막박리