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·Clinical Research·

The measurement of anterior chamber depth and axial length with the IOLMaster compared with contact ultrasonic axial scan

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Abstract

• AIM: To compare the measurement of anterior chamber depth (ACD) and axial length (AL) by IOLMaster and contact ultrasonic (US) axial scan (A-scan).

• METHODS: Measurements of ACD and AL were prospectively obtained in 137 eyes of 121 subjects with the IOLMaster compared with measurements with the US.

• RESULTS: There was an excellent correlation between IOL Master and US measurements for the ACD (r=0.823; P<0.001) and AL (r=0.996; P<0.001). The mean values of the parameters measured by IOLMaster and US were, respectively, as follows: ACD, 2.94± 0.49mm, 2.58± 0.51mm; AL, 24.37± 3.04mm, 23.81± 2.83mm. The mean differences of ACD and AL values between IOLMaster and US measurements were 0.36 ± 0.30mm, 0.56 ± 0.34 mm respectively, and they proved to be statistically significant (P<0.001), with the 95% limits of agreement (LoA) from -0.08mm to +0.38mm for ACD and from -0.09mm to +0.69mm for AL.

• CONCLUSION: As noncontact biometry, IOLMaster provides accurate values. A high degree of agreement between US and IOLMaster was noted. It not only has the advantage of performing noncontact examinations, but also produces various additional data simultaneously and may thus obviate the need for multiple examinations. Further studies are needed to assess the interchangeability of measurements in clinical practice.

• KEYWORDS: anterior chamber depth; axial length; IOLMaster; contact ultrasonic axial scan

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INTRODUCTION

Parallel to the developments of surgical technique in cataract and refractive surgery, the accurate measurement of corneal topography, anterior chamber depth, thickness of the crystalline or artificial lens, and axial length has gained in importance. Until recently, different devices capable of measuring the ACD and AL are based on a variety of techniques and can be classified accordingly. The most commonly used routine method is the A-scan ultrasonic method [1] and its measurements of ACD and AL represent the "gold standard" for this biometric dimension[2]. Yet, with a 10MHz transducer, the resolution of A-scan ultrasound is limited to 200μm and the accuracy is reported to be 70 to 150μm[3]. Other principles used in this regard are photographic and optical methods. However, this method is operator dependent, requiring corneal contact, which may lead to false results due to indentation of the cornea [4]. The measuring results also depend on the exact axial placement of the probe relative to the center of the cornea. Like all contact methods, it may be uncomfortable for the patient or even lead to damage of the corneal epithelium [5]. Thus, noncontact methods are preferred for biometry of the eye [6]. An accurate noncontact ocular biometry technique, based on the dual laser beam partial coherence interferometry (PCI) principle, has been developed in the past decade [7]. The PCI technology has been used for precise AL measurements and resulted in the commercially available IOLMaster (Zeiss Humphrey System CA, USA). However, the IOLMaster uses a photographic (not PCI) technique for measuring ACD[8]. However, little is known about the reliability of the different measuring techniques. In particular, it is not entirely clear whether the results of the two methods (PCI, ultrasonic

Table 1 Comparison of measurements of AL and ACD with IOLMaster and ultrasonic A-scan

Measurement	Ultrasonic A-scan		IOLMaster		Difference (Paired *t* Test)		Correlation (Pearson)		95%LoA
	Mean±SD	Range	Mean±SD	Range	Mean±SD	*P*	*r*	*P*	
AL (mm)	23.81 ± 2.83	18.76-33.68	24.37 ± 3.04	18.95-35.12	0.56 ± 0.34	<0.001	0.996	<0.001	-0.09 to +0.69
ACD (mm)	2.58 ± 0.51	1.56-3.88	2.94 ± 0.49	1.84-4.02	0.36 ± 0.30	<0.001	0.823	<0.001	-0.08 to +0.38

A-scan) are comparable and whether they can be used interchangeably. The purpose of this study was to compare AL and ACD measurements by the IOLMaster with those by the contact ultrasonic A-scan.

MATERIALS AND METHODS

Materials Subjects for this study were consecutive patients attending clinical practice for cataract surgery assessment. 137 eyes of 121 patients (66 females and 55 males) were examined. The mean age of the patients was 67.23±12.18 years (range 24 to 88 years).

Methods Preoperative measurements of ACD and AL were obtained with two methods in the following order- IOL-Master (Zeiss Humphrey System CA, USA) and contact ultrasonic A-scan (Digital 2000, Alcon, USA). Five consecutive AL measurements were registered. The ACD was also measured by using the IOLMaster's built-in facilities and program. For comparison, AL and ACD measurements were also performed by a standard ultrasound technique with a 10MHz A-scan contact probe and topical anesthesia.

Statistical Analysis SPSS 11.5 package was used. For statistical analysis of the difference and the correlation between ultrasound and optical measurements, the paired *t*-test and Pearson correlation method were applied. A value of $P<0.01$ was considered significant.

RESULTS

The mean ACD with ultrasound and IOLMaster was 2.58±0.51mm, 2.94±0.49mm, respectively. The ACD values with the IOLMaster were significantly higher than those with ultrasound. The interdevice differences in ACD between the IOL Master *vs* US was 0.36 ±0.30mm ($P<0.001$). The difference was statistically significant. To assess interdevice agreement and interchangeability, the 95% limits of agreement (95% LoA) was defined. For measurement of ACD, 95% LoA was -0.08mm to +0.38mm for the IOL Master and US (Table 1). The ACD values measured by ultrasound A-scan and by IOLMaster were significantly correlated (r=0.823; $P<0.001$) (Figure 1).

Of the 137 consecutive eyes included in the study, reliable measurements of AL with IOLMaster in 51 eyes could not be obtained because of dense or posterior central cortical capsular cataract or vitreous opacity. The AL values measured by US and by IOLMaster were significantly correlated (r=0.996; $P<0.001$) (Figure 2); however, the IOLMaster values were significantly higher than those of the ultrasound A-scan. The interdevice differences in AL between the IOLMaster vs US was 0.56 ±0.34mm ($P<0.001$). The 95% LoA was -0.09mm to +0.69mm for the measurement of AL (Table 1). Figures 1, 2 illustrated the correlation plots describing agreement in the ACD and AL measurements by two devices (A line of best fit is also included in the graphs).

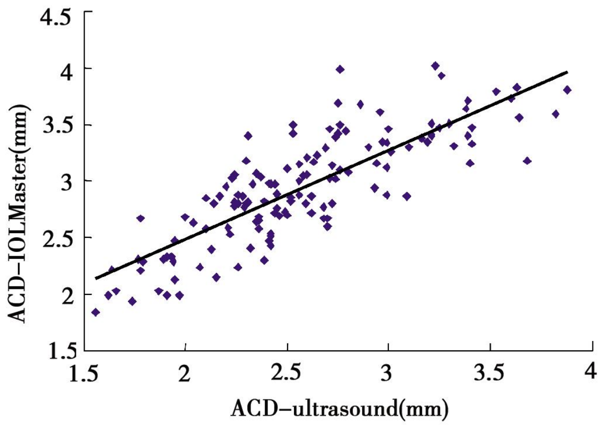

Figure 1 Scatterplot of the correlation between the ACD measured by ultrasound and IOLMaster(r=0.823; $P<0.001$)

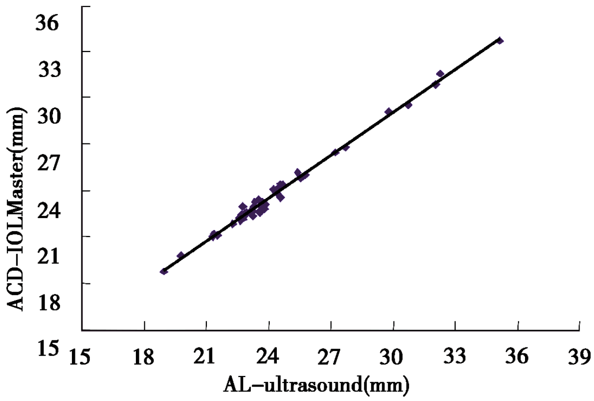

Figure 2 Scatterplot of the correlation between the AL measured by ultrasound and IOLMaster (r=0.996; $P<0.001$)

DISCUSSION

The IOLMaster adopts a non-contact, non-invasive diagnostic imaging technique, which uses infrared diode laser (λ780nm) of high spatial coherence and short coherence length (160μm). The optical scan uses an external Michelson interferometer to split the infrared beam into coaxial dual beams allowing the technique to be insensitive to longitudinal eye movements. Both components of the beam illuminate the eye and are reflected at each interface where a change in refractive index occurs. If the optical path length is within the coherence length an interference signal is detected by a photodetector [9]. This technique, termed PCI, has been extensively used in the determination of corneal thickness [10, 11], anterior chamber depth and lens thickness [12]. The IOLMaster measures the ocular axial length between the corneal vertex and retinal pigment epithelium along the visual axis using a red fixation beam, with a resolution of 12μm and precision of 5μm[13, 14]. ACD is determined by calculating the distance between the corneal and lens surfaces through lateral slit illumination and IOLMaster claims a ±0.01mm resolution for ACD measurements [15]. IOLMaster is another new system that makes axial length, keratometry, and ACD measurements for use in IOL dioptric power calculation.

Several studies assessing the validity of ACD readings with IOLMaster have found statistically significant differences in comparison with ultrasonic values, with an overall overestimation in general [8,15-17]. The results of our study agree with these findings. Some researchers believed that the indentation of the cornea was responsible for shorter biometry values with the ultrasound probe[17-19]. Lam *et al*[8] argued that the difference was not totally attributable to indentation occurring with the contact ultrasound technique, because the difference in their axial length measurements was much less. They believe IOLMaster may not measure the axial ACD because the slit source is always coming from the temporal side, and measuring the ACD away from the center will result in a deeper ACD. Lam *et al* [8] and Sheng *et al* [15] claimed that without cycloplegia, measurements may be influenced by changes in the accommodative state. Kriechbaum *et al* [1] found off-axis measurement a source of error that can arise during ultrasound ACD evaluation; a minor deviation of the correct direction, perpendicular to the 4 major surfaces in the optical axis of the eye, results in shallower ACD readings.

The ACD measurement by US with direct corneal contact may result in inaccurate ACD values caused by indentation of the cornea and shallowing of the anterior chamber with the probe tip of the US device. Another source of error during US ACD measurement is off-axis measurement. The values measured with contact US devices can be distorted by other factors such as the experience of the operator[17], the differences in probe tip handling, and the different settings of US velocity. Moreover, it is time consuming and can be uncomfortable for patients. Therefore, there is increasing demand for more comfortable and faster noncontact methods [20] such as partial coherence interferometry (PCI), Scheimpflug imaging, and AS-OCT[21].

The ALs measured by the optical method were significantly longer than those measured by ultrasound; however, the values obtained by the 2 methods were closely correlated. This difference has also been found in other studies [21, 22] and has been explained by the null-point error of contact A-scan ultrasound biometry, which causes a systematic error. The IOLMaster software is calibrated so that the optically measured value is adjusted by using a regression model to the value measurable by the immersion ultrasound method[13]. Also, the measuring points of the 2 methods are different. The optical method measures from the tear film to the retinal pigment epithelium, while the ultrasound technique measures from the cornea to the vitreoretinal interface. The optical method measures along the optical axis of the eye, while the ultrasound technique more likely measures on the anatomic axis. During contact ultrasound measurements, the probe can applanate the cornea, shortening the AL by an average of 0.1 to 0.3mm [23]. Optical measurement is less dependent on the observer and can be performed by an ophthalmic assistant, while ultrasound A-scan biometry requires a trained, experienced observer.

We did not evaluate that in which of these measurement the postoperative refraction was near plano or postoperative uncorrected visual acuity was higher. Anyway, with which of these methods, our values were near to true axial length so that with application of those values postoperative refractions were near plano. We recommend a larger study to compare these values with application of two methods to patients postoperatively.

In summary, based on up-to-date reports and our results, PCI seems to be a reliable method for measuring the AL and ACD optically. The results are as accurate as contact ultrasound but are obtained by a noncontact technique, so no anesthesia is needed and infection is avoided. A further advantage is the ease of use so that a medical assistant can perform the measurements. A disadvantage of the

IOLMaster is that it costs more than basic but high-quality ultrasound and keratometer instruments. Another disadvantage is that in eyes with dense cataract and/or in which the clarity of the optical media is decreased, the optical method is not applicable. But it also produces various additional data simultaneously and may thus obviate the need for multiple examinations.

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