Measurement of White-to-White Distance Using Pentacam Scheimpflug Imaging versus IOLMaster

Mohammed W. Elkateb, Hesham S. Swelem

Department of Ophthalmology, Faculty of Medicine, University of Alexandria, Alexandria, Egypt

Correspondence to Hesham S. Swelem, MD, Alexandria Faculty of Medicine, Al-Messalah Post office, Alexandria 21521, Egypt
Tel: +20 348 34330; fax: +20 348 33067;
e-mail: shafik@doctorsorg.uk

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Purpose
The aim of this study was to assess white-to-white (WTW) horizontal corneal diameter using Pentacam versus IOLMaster and determine whether the two instruments were interchangeable.
Patients and methods
Twenty eyes were included in this prospective clinical study conducted in I-care Eye Centre, Alexandria. Measurement of WTW horizontal corneal diameter was taken using Pentacam (internal and external measurements) and IOLMaster.
Results
The mean WTW measured using IOLMaster was 11.66 ± 0.27 mm, ranging from 11.30 to 12.30 mm. The mean WTW externally using Pentacam was 11.93 ± 0.43 mm, ranging from 11.01 to 12.66 mm. The mean WTW internally using Pentacam was 11.20 ± 0.39 mm, ranging from 10.56 to 11.93 mm. The diameters measured using IOLMaster were significantly less than that measured using Pentacam externally and significantly more than that measured using Pentacam internally. There was no correlation between WTW measured using the two machines.
Conclusion
Although horizontal corneal diameter (WTW) can be measured using Pentacam or IOLMaster, WTW measurement is significantly different between the two instruments and they should not be used interchangeably. Pentacam measurement depends on manual placement of calipers on the Scheimpflug digital image.

Keywords:
IOLMaster, Pentacam, white-to-white

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Introduction

Measurement of horizontal corneal diameter, known as white-to-white (WTW) distance, is important in cataract and refractive surgery as a part of preoperative evaluation [1,2]. Corneal diameter is one of the most important geometrical parameters of the cornea. It is essential in estimating the internal anterior chamber width, ciliary sulcus diameter and even corneal endothelial cell density [3,4]. Proper sizing of an anterior chamber intraocular lens (IOL), an iris fixated IOL and a capsular tension ring is dependent on accurate estimation of WTW. Very accurate estimation of WTW is also crucial in choosing the proper size of an implantable contact lens. Some IOL formulae incorporate corneal diameter into the calculation of the IOL power. Different methods have been used to estimate WTW, including manual caliper measurement, corneal topography, Scheimpflug imaging, partial coherence interferometry, anterior segment optical coherence tomography and ultrasound biomicroscopy. However, different modalities give slightly different readings, which adds to the perplexity of choosing an accurate WTW. Partial coherence interferometry (optical coherence biometry) represents a recent innovation to improve the accuracy and ease of IOL power calculations and offers the ease of obtaining keratometry values, anterior chamber depth and axial length measurements in a single setting [3]. This noncontact technique is a significant advantage when compared with conventional ultrasound biometry, which demands topical anaesthesia for corneal applanation and is time consuming. Moreover, the precision achieved with partial coherence laser interferometry was shown to be 10 times better than that of ultrasound in earlier studies [4–6].

The Pentacam rotating Scheimpflug camera imaging is a rapid novel noncontact modality for studying the anterior segment of the eye using a blue light emitting diode and a rotating Scheimpflug camera. Topography, corneal thickness, corneal curvature and anterior chamber angle, volume, and height are calculated from up to 25 000 data points. It has

widespread applications in measuring anterior segment parameters [6].

This study aimed to compare the WTW distances measured using a Pentacam versus IOLMaster.

Patients and methods

This study included 20 eyes of 10 randomly selected volunteers. Informed consent was obtained from all participants. The study was conducted in I-care Eye Centre in Alexandria (Ethics Committe at Faculty of Medicine, Alexandria University, has approved this study). For optical coherence biometry, the IOLMaster (Carl Zeiss Meditec AG, Dublin, CA, USA) was used. Corneal power was assessed using a built-in automated keratometer. Axial length measurement was taken using the principle of partial coherence interferometry. At least 10 measurements were taken. The computed average of five selected measurements with the highest signal-to-noise ratio was taken. Horizontal WTW values were recorded. Using the Pentacam rotating Scheimpflug camera, the patient was asked to fixate straight ahead on the blue circular fixation target. The operator focused and aligned the real-time image of the patient's eye on the computer monitor with the machine marking the pupil edge, centre and the corneal apex. Arrows displayed on the screen guided the operator to align the instrument in the horizontal and vertical axes. To reduce operator-dependent variables, the automatic release mode was used wherein the device automatically determined when the image was in focus and the corneal apex correctly aligned. The rotating camera captured up to 25 slit images of the anterior segment in less than 2 s. The software constructed a three-dimensional image of the anterior segment, which gave information about the anterior and posterior surfaces of the cornea and anterior chamber. The ACD in mm was calculated using the machine in the three-dimensional model from the back surface of the cornea to the anterior lens surface with undilated pupil. Horizontal WTW was measured by manual placement of calipers on the Scheimpflug image; both internal and external anterior chamber horizontal diameters were recorded (Fig. 1).

Data were statistically analysed using SPSS software package, version 20.0 (SPSS Inc., Chicago, Illinois, USA). For comparison between the two instruments, the analysis of variance test with repeated measures was used and the post-hoc test results were subjected to Bonferroni adjustment. Correlations between IOLMaster and Pentacam WTW measurements were assessed using Pearson coefficient. Agreement of techniques was assessed using the interclass correlation coefficient. Significance of the obtained results was judged at the 5% level.

Results

This study included 20 eyes of 10 randomly selected patients. As regards Pentacam measurements of WTW, there were internal and external measurements according to the choice of manual caliper placement. Table 1 shows the WTW measurements of both IOLMaster and Pentacam. The mean WTW using IOLMaster was 11.66 ± 0.27 mm, ranging from 11.30 to 12.30 mm. The mean WTW externally using Pentacam was 11.93 ± 0.43 mm, ranging from 11.01 to 12.66 mm. The mean WTW internally (angle-to-angle distance) using Pentacam was 11.20 ± 0.39 mm, ranging from 10.56 to 11.93 mm. The diameters measured using IOLMaster were significantly less than that measured using Pentacam externally and significantly more than that measured using Pentacam internally (Table 2). Analysis using Pearson coefficient and interclass correlation coefficient showed that there was no correlation between WTW measured using the two machines (Table 3).

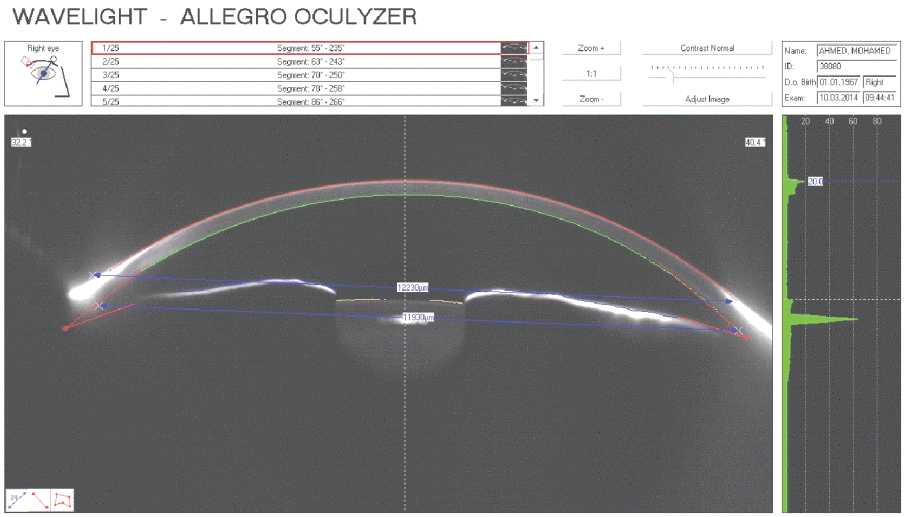
Discussion

In view of increasing popularity of newer generations of phakic IOLs, the need for precise measurement of

Table 1 WTW measured using IOLMaster and Pentacam (mm)

Eye studied	IOLMaster	Pentacam	
		Internal	External
1	11.4	11.3	11.9
2	11.4	11.67	12.62
3	11.4	10.85	11.83
4	11.4	11.02	11.84
5	11.7	11.12	11.9
6	11.6	11.47	12.66
7	11.3	11.55	12.03
8	11.5	11.26	12.19
9	11.3	10.64	11.01
10	11.6	10.75	11.68
11	11.9	11.63	11.95
12	11.9	10.98	11.48
13	11.6	10.56	11.25
14	11.5	10.71	11.56
15	12.0	11.93	12.23
16	12.0	10.95	11.54
17	11.7	11.57	12.0
18	11.7	11.06	12.09
19	12.3	11.58	12.58
20	11.9	11.42	12.17

Figure 1



Caliper placement on the Scheimpflug image for the measurement of internal and external anterior chamber horizontal dimensions.

Table 2 Comparison between mean WTW using IOLMaster and Pentacam

	IOLMaster	Pentacam		*F*
		Internal	External	
Minimum–maximum	11.30–12.30	10.56–11.93	11.01–12.66	26.58*
Mean ± SD	11.66 ± 0.27	11.20 ± 0.39	11.93 ± 0.43	
P_1		<0.001*	0.045*	
P_2		<0.001*		

ANOVA, analysis of variance; *F*, *F*-test (ANOVA) with repeated measures; WTW, white-to-white. P_1: adjusted Bonferroni *P*-value for ANOVA comparing IOLMaster and internal and external Pentacam. P_2: adjusted Bonferroni *P*-value for ANOVA comparing internal and external Pentacam. *Statistically significant at $P \leq 0.05$.

Table 3 Correlation between WTW values of IOLMaster and Pentacam

	Mean difference (mm)	*r* (*P*)	ICC (*P*)
IOLMaster vs. Pentacam external	↓0.27	0.245 (0.297)	0.178 (0.168)
IOLMaster vs. Pentacam internal	↑0.45	0.344 (0.138)	0.172 (0.077)

ICC, interclass correlation coefficient; *r*, Pearson coefficient; WTW, white-to-white. Significance of ↓ and ↑ at increased and decreased.

WTW horizontal corneal diameter has regrown. One of the most important ways to avoid phakic IOL-induced complications, such as pupillary block and cataract formation, is to achieve the proper distance between the back surface of the IOL and the anterior pole of the crystalline lens [7]. This distance, known as vaulting, is highly dependent on the chosen phakic IOL diameter. Kamiya *et al.* [8] found patient age and WTW to be the most significant factors affecting vault.

The normal range of horizontal corneal diameter is rather somewhat variable between studies, partially depending on the modality used for measurement, and is reported to be between 11.5 and 12.5 mm [5,9,10]. A Korean study using Orbscan reported WTW on 2000 participants to be 10.5–13.4 mm, with a mean of 11.5 mm [11]. The Orbscan, for example, uses digital image processing for WTW measurements. A digital grey scale image of the anterior segment is reconstructed and the computer automatically detects the corneal limbus by comparing the grey scale steps and hence calculates the corneal diameter.

Different methods have been used for the measurement of WTW and can be divided into two groups: manual and automated methods. Millimetre rules, calipers, gauges, or scales in slit-lamp oculars are all devices for manual determination of WTW diameter. Manual methods described in different studies vary significantly and have a relatively great range of variance [10]. The comparatively poor repeatability of the caliper may be because the least count of surgical caliper is 1 mm. The IOLMaster, based on the principle of dual-beam interferometry, which is insensitive to longitudinal eye movements and uses the cornea as the reference surface, has been demonstrated to measure with precision and

accuracy the axial length of normal and cataractous eyes. It uses infrared of short coherence for the measurement of optical axial length, which is converted to geometric axial length using group refractive index. The measured optical distances are divided by the group refractive indices to obtain geometric distances. It also measures the corneal curvature, anterior chamber depth and corneal diameter [10,11]. WTW is measured based on a digital photographic image that it acquires. The IOLMaster then digitally locates the limbus based on a sudden change in the contrast from bright sclera to dark cornea. This contrast difference can vary depending on illumination and quality of the image. The current study found WTW using IOLMaster to be 11.30–12.30 mm, with a mean of 11.66 ± 0.27 mm. This was significantly less than WTW measured externally using Pentacam, ranging from 11.01 to 12.66 mm (mean 11.93 ± 0.43 mm), and more than the mean WTW measured internally (angle-to-angle distance) using Pentacam (11.20 ± 0.39 mm). This could be explained by the different measurement techniques between the two instruments. Moreover, neither instrument is free from defects, preventing exact measurement, as pointed out. The Pentacam depends on the operator manually placing measuring calipers on the digital image to define the limbus limits for measurement, either internally or externally (Fig. 1). This is a highly subjective endpoint, made more difficult by the fact that the limbus on the digital image is not a clear-cut boundary, because the white sclera reflects the visible blue light (475 nm) of the Scheimpflug and much 'noise' is created. Kiraly *et al.* [12] found the mean WTW for 50 patients using IOLMaster 500 to be 11.98 ± 0.37 mm, whereas the mean angle-to-angle internally using Pentacam was 10.73 ± 0.38 mm. When compared with the current study in Pentacam internal dimensions; and despite of the small sample size, this highlights the interobserver variability in manually determining the angle limits and subsequent caliper placement on the Scheimpflug image. Dinc *et al.* [13] also reported the mean internal anterior chamber diameter for 40 patients using Pentacam to be 11.61 ± 0.58 mm, again showing the subjective nature of the technique. The same study found the mean WTW using IOLMaster to be 11.87 ± 0.35 mm and the authors emphasized the interdevice differences.

In addition, a German study demonstrated that Pentacam determined angle-to-angle distances that were up to 1.30 mm smaller than WTW distances measured with IOLMaster [14]. This is in accordance with the current study in which internal measurement of anterior chamber diameter using Pentacam underestimated WTW (mean 11.20 ± 0.39 mm) compared with IOLMaster (mean 11.66 ± 0.27 mm), the difference being highly significant. Because of the haptics of the implantable collamer phakic IOL rest in the sulcus, the ideal overall diameter of the phakic IOL depends on the ciliary sulcus diameter. Thus, it is desirable to obtain a direct measurement of the sulcus-to-sulcus length using newer technologies [15]. Regardless of the accuracy of the WTW measurement, recent studies found no anatomic correlation between external measurement and internal sulcus-to-sulcus diameter. Therefore, WTW distance alone may not predict angle or sulcus size [16,17]. Manufacturer's nomograms, however, still depend on manual WTW measurement using surgical calipers; in fact, they lag behind measurement technologies at present, and hence it is difficult to extrapolate measurements from IOLMaster, Pentacam, and other instruments to the IOL nomograms.

Conclusion

The current study has shown that WTW horizontal corneal diameter as measured using IOLMaster and Pentacam is not identical and both instruments are not interchangeable. Pentacam overestimates WTW diameter when measured externally when compared with IOLMaster and underestimates it when measured internally.

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Nil.

Conflicts of interest

There is no financial interest in any of devices or techniques used in this study.

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