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Agreement of HVID/WTW measurements made by 5 devices and their correspondence to the distance from angle to angle (ATA)

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Purpose: to determine the consistency of HVID/WTW measurements on 5 devices, and their correspondence to the distance from angle to angle (ATA).

Methods. The relevant information on 30 right eyes was obtained from 30 volunteers. A prospective study was conducted using Wavelight Topolayzer Vario (Alcon), IOL Master 700 (Zeiss), OA2000 (Tommy), AS-OCT Casia 2 (Tommy), Zeiss Atlas 9000 (Carl Zeiss) instruments. Agreement between the measurements made by these devices in the HVID/WTW was analyzed, and the HVID/WTW scores of each device were compared with ATA scores.

Results. The average values of HVID/WTW in Wavelight Topolayzer Vario, IOL Master 700, OA2000, Zeiss Atlas 9000 devices were 11.73 ± 0.33 mm, 12.01 ± 0.34 mm, 12.01 ± 0.27 mm, and 12.2 ± 0.37 mm, respectively. The mean ATA was 11.68 mm on the AS-OCT Casia2 device. The smallest difference in ATA and HVID/WTW was observed on the Wavelight Topolayzer Vario instrument which averaged 0.05 ± 0.102 mm 95% LoA (-0.41 to 0.32) ($p < 0.05$). The largest difference was observed between AS-OCT Casia 2 and Atlas 9000 which averaged 0.52 ± 0.234 mm 95% LoA (from -1.21 to 0.17) ($p < 0.05$).

Conclusion. Our study found that the results of measurements of HVID/WTW on the Wavelight Topolayzer Vario device are optimal when compared with ATA.

Keywords:

cataract surgery, HVID/WTW, angle to angle distance

Introduction. Implantation of posterior chamber phakic intraocular lenses (PIOL) is a safe and effective surgical method for correction of refractive abnormalities [1]. Choosing the right size is fundamental for achieving an optimal postoperative arch. An accurate length calculation can prevent postoperative complications such as endothelial cell loss, cataract formation, chronic inflammation, and increased intraocular pressure [2]. Currently, white-to-white corneal ratio (white-to-white WTW) or horizontal visible iris diameter (HVID) is one of the main parameters used to calculate PIOL size as recommended by the manufacturer [3]. WTW represents the horizontal distance between the borders of the corneal limb. When calculating PIOL, a constant value is added to the horizontal distance from WTW)- usually from 0.5 to 1.0 mm [4].

There are several methods that are commonly used to measure HVID/WTW distance. These can be divided into manual methods such as surgical calipers and automated methods, namely ultrasound biomicroscopy, anterior segment optical coherence tomography (AS-OCT) and direct imaging techniques. It was previously proven that measurements in an automated device give more accurate results than measurements in manual devices

However, previous studies have shown that the WTW horizontal diameter can vary significantly even between automated devices, resulting in a significant difference in ICL sizes in 37.3% of cases [5].

It is currently known that angle-to-angle (ATA) or spur-to-spur (STS) distances are the most appropriate values for calculating the size of phakic IOLs. Internal distances are always preferable to external distances [6-10].

The **purpose** of our study was: to determine the interchangeability of HVID/WTW measurements 5 devices, as well as their accordance to the distance from angle to angle (ATA).

The ongoing study is aimed at analyzing the diversity of methods used to measure HVID/WTW distance, the clinical importance of repeating HVID/WTW measurements and agreement between devices as well as their accordance to angle-to-angle (ATA) distance. The measurements were carried out the following devices: Wavelight Allegro topolizer, IOL Master 700 optical biometer, OA2000 optical biometer, front OCT-AS Casia 2, Zeiss Atlas 9000 keratopograph.

Materials and methods

This study involved 30 healthy participants (30 right eyes), aged 18 to 45 years (22.3 ± 4.2 on average). The exclusion criteria were as follows: corneal abnormalities, active eye pathology, corneal opacity, fixation instability. All participants were employees of the Saif-Optima clinic; the study was conducted during the week. The study was

approved by protocol № 17 Ethic Committee. Prior to obtaining their consent, all participants were informed and expressed their understanding of the study objectives and procedures in accordance with the provisions of the Declaration of Helsinki.

In our study, the right eyes of each participant were selected and then scanned three times. During the examination session, each device took six high-quality images for each object. All measurements were carried out in a medium-illuminated room without the use of eye drops. Participants were asked to place their chin on the chinrest in the device and close their eyes completely before each measurement to ensure sufficient tear to cover the cornea. They were then asked to open their eyes, look straight ahead and not change the direction of their gaze during the scan.

After the scan was completed, only the optimal quality scans were selected. The "acceptable quality" determination is based on the criteria provided by the manufacturer of each device.

Devices

The devices define HVID/WTW differently. The operation of the Wavelight Topolayzer Vario diagnostic device is based on a Placido disk system consisting of 22 measuring rings with 22,000 reference points or elevation points, and includes optimized detection of the edge by subpixel approximation to 1/10 pixel.

Then the Placido disk image is extracted to automatically calculate the HVID/WTW distance.

IOL Master 700 measures HVID/WTW from the front segment Infrared digital halftone photo taken after focusing on the iris by automatic limb detection.

Optical biometer OA-2000 is based on SS-OCT technology with a scanning speed of 1250 scans/s and a wavelength of 1060 nm, a Placido disk consisting of 9 rings (each with 256 dots) is projected onto the cornea.

AS-OCT CASIA2 is a device for optical coherence tomography of the front-segment with an oscillating source and a wavelength of 1310 nm; it performs measurements by 50,000 axial scans per second. In Front Segment mode, each 3D image consists of 128 V scans. These images automatically determine the ATA dimensions.

Atlas 9000 uses a 22-ring Placido disc with automatic measurement of horizontal diameter of visible HVID iris.

Statistical analysis

Statistical processing of the study findings was carried out using specialized software: Statistica 10.0 computer programs (StatSoft, USA) and Microsoft Office Excel 2019 (Microsoft, USA). The nature of the data distribution was assessed using the Kolmogorov-Smirnov test. The obtained data were analyzed by methods of descriptive statistics and were presented in $M \pm \sigma$ format, where M (Mean) is the arithmetic mean, σ is the standard deviation. The variation of values and their displacement relative to each other were evaluated using the descriptive Bland-Altman method for assessment of the consistency of measurements performed in two different ways. In addition, the following figures were calculated and presented on the

graphs; mean difference, 95% confidence interval of mean difference, and 95% limits of agreement (LoA).

The Student t-test for independent and dependent samples was used to compare the means and assess the validity of the differences. The critical level of statistical significance when testing the null hypothesis was assumed to be 0.01. If parametric analysis is not possible, the Wilcoxon test and the Mann-Whitney U test were used. The differences where the confidence level (p) is less than 0.05 ($p < 0.05$) were statistically significant.

Results

Mean values \pm standard deviation of analyzed HVID/WTW distances on devices: Wavelight Topolyzer Vario, IOL Master 700, OA 2000, Atlas 9000, AS-OCT Casia 2.

The solid lines show the mean of the difference between the two devices, and dashed lines represent 95% of the match limits (95% LoA)

As can be seen from the graphs, the smallest difference between ATA and HVID/WTW was observed between AS-OCT Casia 2 and Wavelight Topolyzer Vario and averaged 0.05 ± 0.102 mm 95% LoA (from -0.41 to 0.32) ($p < 0.05$).

In a pair of AS-OCT Casia 2 IOL/Master 700 devices, the difference was on average 0.33 ± 0.175 mm 95% LoA (from -0.85 to 0.16) ($p < 0.05$).

The difference in AS-OCT Casia/OA 2000 instruments averaged 0.32 ± 0.189 mm 95% LoA (-0.7- 0.06) ($p < 0.05$).

The largest difference was observed between AS-OCT Casia 2 and Atlas 9000, and averaged 0.52 ± 0.234 mm 95% LoA (from -1.21 to 0.17) ($p < 0.05$).

Discussion

Accurate measurement of HVID/WTW is important for calculation of PIOL size, and accordingly, the value of the vault in the recommended range of values.

The corneal scleral limb is histologically complex, and the interface of the transition points between the sclera and the cornea does not exactly coincide superficially and in depth. Therefore, several definitions of histological and

Table 1. Mean values \pm standard deviation of analyzed HVID/WTW distances on devices: Wavelight Topolyzer Vario, IOL Master 700, OA 2000, Atlas 9000, AS-OCT Casia 2.

Приборы	HVID/WTW mean \pm SD (mm)	CI 95%
Wavelight Topolyzer Vario	11.73 \pm 0.34	0.13
IOL Master 700	12.01 \pm 0.34	0.10
OA 2000	12.01 \pm 0.34	0.13
Atlas 9000	12.2 \pm 0.37	0.14
AS-OCT Casia2 ATA mean \pm SD (mm)SD	11.68 \pm 0.36	0.14

SD- Standard deviation, CI 95% -95% confidence interval, WTW -white to white spacing, HVID - horizontal visible iris diameter, ATA - distance between corners

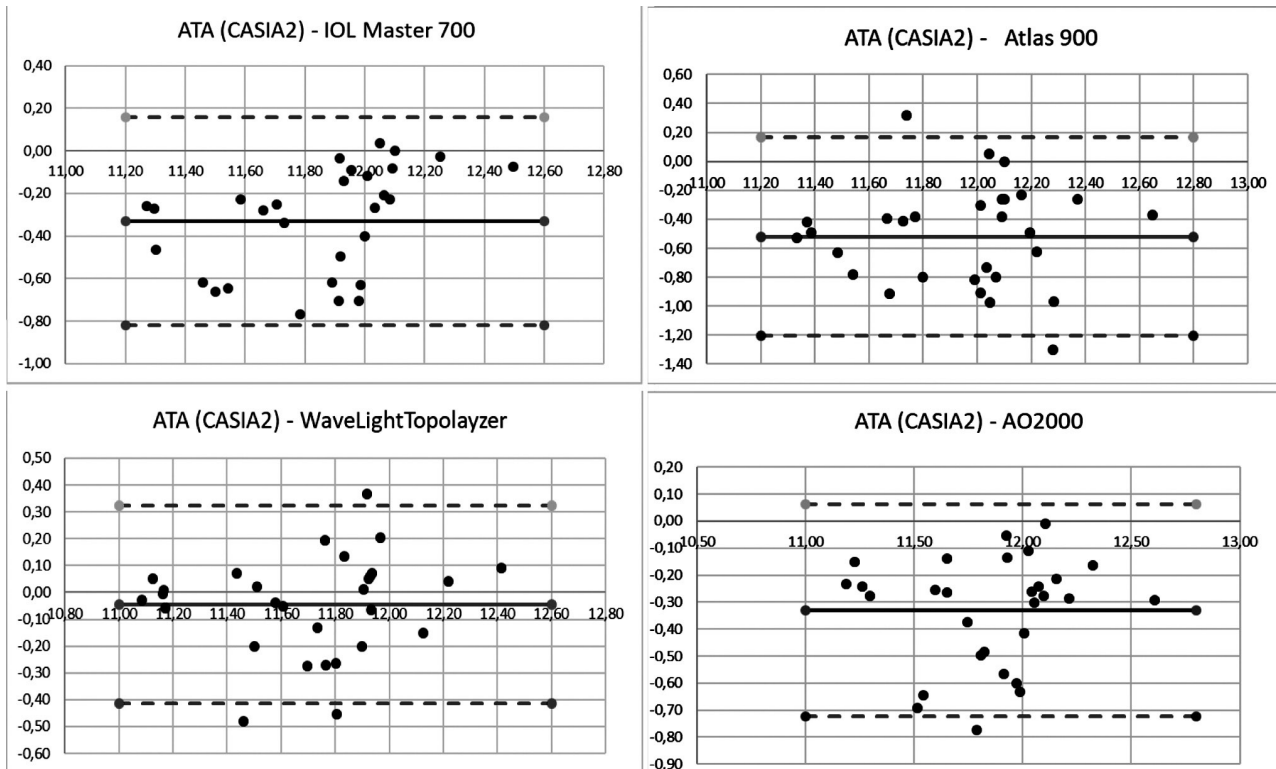


Figure 1. Bland-Altman plots for measurements of the HVID/WTW on 5 devices to compare them with the ATA (mm).

clinical limbs were proposed. Clinical definition continues to be based on the determination of the inner boundary of the blue-gray ring of the cornea (i.e. HVID/WTW) and clinical labeling of limb as a strip of tissue 1.5 to 2.0 mm wide which surrounds it [2].

The uncertain nature of the gray-blue corneal ring makes HVID/WTW an inherently subjective measurement. Various studies have reported measurements of HVID/WTW in normal individuals using a variety of devices. Although the HVID/WTW distance can be measured manually using calipers, automated devices, that typically detect the corneal limb by comparing gray scale steps, produce a more accurate and reliable reading [1,4,7,8].

Our study examined the reproducibility of HVID/WTW measurements using 4 tools: Wavelight Topolyzer Vario, IOL Master 700, OA 2000, Atlas 9000, and AS-OCT Casia 2 - ATA size match.

Angle-to-angle (ATA) or spur-to-spur (STS) distances are the most appropriate values for calculating the size of the front segment phakic IOLs. Similarly, for phakic IOLs of the posterior segment, their size should be calculated using the distance from the white-to-white. For clinical purposes (i.e. lens sizing), we can consider both parameters (ATA and STS) similar. In this context, internal distances are always preferable to external distances. Over the past two decades, several authors have evaluated WTW, ATA, STS, using a variety of devices [2-6.8]. Therefore, we used the ATA distance as a reference

The Lens Sizing Protocol, originally approved by the U.S. FDA in 2005, requires the addition of 0.5 mm to the horizontal measurement of white-to-white obtained using a slit lamp caliper or using an Orbscan (2.17) Buckingham Boyle A. When comparing IOL Master 700, Galilei G2 and DRI OCT Triton with Orbscan Iiz, it was noted that all three devices produce a larger WTW/HVID measurement than Orbscan Iiz. (11)

Nonpassopon M et al. determined that the mean WTW measured with Orbscan Iiz and Topolyzer demonstrated good overlap (P 0.884) with low systematic deviation (-0.03 ± 0.1 mm) [17].

In our study, all pairwise comparisons revealed statistically significant differences in the mean measurement of HVID/WTW versus ATA, except for the HVID/WTW pair on the Wavelight Topolyzer Vario and the ATA on the AS-OCT Casia 2.

As a result, it was revealed that the measurements of HVID/WTW, on the Wavelight Topolyzer Vario device, can be used as optimal when compared with ATA. And in particular, it is used to calculate the PIOL in the absence of devices that measure internal distances.

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Information about authors and disclosure of information

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Conflict of interest: No.

Statement of Ethics. This study followed the tenets of the Helsinki Declaration and was approved by Saif-Optima Eye Clinic Ethics Board, Tashkent, Uzbekistan (protocol №17). Written informed consent was obtained from the patients for publication of the details of their medical case and any accompanying images.

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