Anterior chamber depth measurement: interchangeability between Pentacam and other devices

Alberto Domínguez-Vicent, MSc1; Daniel Monsálvez-Romín, OD1; Vicent Sanchis, MSc1; Santiago García-Lázaro, OD, PhD1; Robert Montés-Micó, OD, PhD1.

ABSTRACT: We reviewed a series of recently published studies in which the anterior chamber depth (ACD) distance was measured by Pentacam or Pentacam HR and compared with other measuring devices. Since some published studies reach contradictory conclusions regarding device interchangeability and include different ocular conditions, for instance, phakic eyes, pseudophakic eyes, cataractous eye, and so on, this review was carried out to try to clarify which clinical devices can or cannot be considered as interchangeable with Pentacam or Pentacam HR for the measurement of ACD distance in clinical practice.


Nowadays, the measurement of anterior chamber depth (ACD) distance has become increasingly important in ophthalmic practice, for instance, in the planning of cataract1-5 and refractive 1-9 surgery, calculation of phakic or pseudophakic IOL power and diameter4,5,10-14, screening for glaucoma risk factors2,3,14-16, and so on. Many papers focusing on device interchangeability for the measurement of ACD distance have been published. However, the studies published include different ocular conditions.

For this reason, we decided to review all studies published in Medline before August 2012. The inclusion criterion was that the study had to evaluate device interchangeability between Pentacam or Pentacam HR and other devices that measure ACD distance.

The devices included in this review were Pentacam (Oculus, Wetzlar, Germany), Pentacam HR (Oculus, Wetzlar, Germany), A-Scan, Ultrasound Biomicroscopy (UBM), Orbscan (Bausch&Lomb Surgical Inc., San Dimas, California, USA), Orbscan II (Bausch&Lomb Surgical Inc., San Dimas, California, USA), Galilei (Ziemer, Switzerland), Visante OCT (Carl Zeiss Meditec Inc., Dublin, California, USA), IOLMaster (Carl Zeiss Meditec, Jena, Germany) and Lenstar LS 900/Biograph (Haag-Streit AG, Koeniz, Switzerland/Alcon Laboratories Inc., Ft Worth, Texas, USA). In this context, the purpose of this paper was to clarify which devices are interchangeable with Pentacam or Pentacam HR in the measurement of ACD distances. We also included a brief description of the measurement principle used by the devices included in this review.

MEASUREMENT PRINCIPLES

Pentacam

The Pentacam is a non-contact device using a rotating Scheimpflug camera. It uses a monochromatic slit light source to measure anterior segment topography. Up to 50 slit images with 500 measurement points on the front and back of the corneal surface are acquired in 2 seconds over a 180-degree rotation. The internal software creates a three-dimensional reconstruction of the anterior segment by using the elevation data of these images, which gives information about the anterior and posterior surface of the cornea, and ACD from endothelium to crystalline lens.
**Pentacam HR**

Pentacam HR (Figure 1 left) is one of the latest developments in three-dimensional topographers and is based on the Scheimpflug principle. The rotating camera rotates around the optical axes of the eye to calculate a three-dimensional model of the anterior segment. The system has two different three-dimensional modes. One is a regular three-dimensional scan that takes 50 images in 2 seconds. The other is a special three-dimensional high-resolution corneal mode, in which the camera takes 50 images per second. The internal software creates a three-dimensional reconstruction of the anterior segment by using the elevation data of these images, giving information about the anterior and posterior surface of the cornea, and ACD from endothelium to crystalline lens.

**A-Scan**

This ultrasound contact device, which works at 10-MHz, is used to measure eye biometric dimensions, i.e., axial length, anterior chamber depth, posterior chamber depth and corneal and lens thickness. It calculates ACD on the basis of the difference in the time taken for ultrasound waves to reflect back to its receiver from the posterior corneal surface and anterior lens surface.

**Ultrasound Biomicroscopy**

This ultrasound contact device, which works at 50 MHz, is used to image ocular tissue depths up to 4 to 5 mm with lateral and axial physical resolution of approximately 50 and 25 µm. ACD is measured with a ruler over the sonogram.

**Orbscan**

The Orbscan is a noncontact topography system that is used for anterior segment evaluation. It uses two different techniques: a Placido disk system, which screens anterior corneal topography and creates an elevation map; and a horizontally moving scanning camera, which acquires slit images. After image reconstruction, a mathematical three-dimensional model of the cornea and the anterior segment is calculated. To calculate the ACD, the system software automatically detects the corneal endothelium surface and anterior surface of the crystalline lens on the acquired images.

**Orbscan II**

The Orbscan II (Figure 2 left) is a non-invasive topography system that scans the anterior segment, combining a three-dimensional scanning slit beam system with an added Placido attachment for evaluating corneal surfaces. This device calculates ACD in the same manner as Orbscan.

**Galilei**

The Galilei (Figure 1 right) is a non-invasive diagnostic system designed for the analysis of the anterior eye segment. The system is based on a rotating dual-Scheimpflug camera integrated with a Placido topographer. This device captures slit images from opposite sides of the illuminated slit and averages the elevation data obtained from corresponding opposite slit images. This dual Scheimpflug imaging technique improves the detection of the posterior corneal surface and provides outstanding accuracy in pachymetry across the entire cornea, even when the camera is decentered because of eye movements.

**Visante OCT**

Visante OCT (Figure 2 right) is a time-domain non-invasive system that employs high-resolution images. The light source is a superluminescent light-emitting diode with a short wavelength that has
a limited penetration depth into the eye. By moving the scanning spot laterally across the eye, this device acquires multiple A-Scans and aligns them to construct two-dimensional images analogous to an ultrasound B-scan. The scanning speed is 4,000 axial scans/second and each image frame has 500 axial scans/image. It can be used to measure central corneal thickness and ACD.

**IOLMaster**

The IOLMaster (Figure 3 right) is designed to measure the parameters used in intraocular lens (IOL) calculation, including axial length, corneal curvature, ACD and WTW distance. The IOLMaster emits 780-nm infrared light and uses partial coherence interferometry to measure axial length. Keratometry and ACD are determined automatically using a lateral slit illumination of the corneal and crystalline lens and a white-light-emitting diode of 590 nm as the light source. The lateral slit illumination is 0.7 mm wide and employed at an angle of 30 degrees during ACD measurements.

**Lenstar**

The Lenstar (Figure 3 left) optical biometer is based on low coherence reflectometry, with an 820-mm superluminescent diode. The Lenstar detects anterior and posterior corneal and anterior crystalline lens peaks in the optical low coherence reflectometry waveform to measure the ACD and corneal thickness. In addition to ACD and corneal thickness, the Lenstar also measures axial length.

**ANTERIOR CHAMBER DEPTH**

Each study included in this study compared Pentacam or Pentacam HR with one of the following devices: A-Scan, UBM, Orbscan, Orbscan II, Galilei, Visante OCT, IOLMaster, Lenstar and MRI.

**Pentacam vs. A-Scan**

Németh et al.\(^7\), Elbaz et al.\(^7\) and Su et al.\(^8\) studied the interchangeability of Pentacam and A-Scan. These authors included normal eyes in their sample but reached different conclusions: while Németh et al.\(^7\) obtained comparable ACD values, Elbaz et al.\(^7\) and Su et al.\(^8\) obtained significantly lower ACD values with A-Scan. However, in these two latter studies the mean difference lay within clinical tolerance limits. Németh et al.\(^7\) and Su et al.\(^8\) also included pseudophakic eyes in their sample and in these cases the ACD values provided by A-Scan and Pentacam were not comparable. Therefore, it can be concluded that A-Scan and Pentacam can be used interchangeably in clinical practice for phakic subjects, but not for pseudophakic eyes.

**Pentacam HR vs. A-Scan**

Szalai et al.\(^9\) compared ACD measures provided by Pentacam HR and A-Scan. They observed that A-Scan yielded significantly higher ACD values than Pentacam HR, thus concluding that these two devices cannot be assumed to be interchangeable in clinical practice. However, for IOL power calculation these devices can be used interchangeably, since the mean difference between these two devices is within clinical tolerance limits.

**Pentacam vs. Orbscan**

Lackner et al.\(^12\), Kiraly et al.\(^20\) and Yazici et al.\(^21\) compared Orbscan with Pentacam, but the results they achieved were rather contradictory. Lackner et al.\(^11\) obtained significantly higher ACD values with Orbscan, while in contrast, in the study of Yazici et al.\(^21\), it was Orbscan that produced significantly lower ACD values. However, the mean difference observed by Lackner et al.\(^11\) and by Yazici et al.\(^21\) was within clinically acceptable levels, which is why these two authors concluded that these devices can be used interchangeably.

**Pentacam vs. Orbscan II**

Five studies\(^6,15,16,23,24\) evaluated the interchangeability between Orbscan II and Pentacam. Doors et al.\(^9\), Dinc et al.\(^16\), Hashemi et al.\(^23\) and Kim et al.\(^24\) obtained statistically significant differences between the values produced by these two devices, thus concluding that they should not be used as though they were interchangeable. In contrast, Utine et al.\(^15\) did not observe any statistically significant differences between Orbscan II and Pentacam, thus assuming their interchangeability. It is worth mentioning that the mean difference between Orbscan II and Pentacam was within clinically acceptable tolerance limits in four\(^6,15,16,24\) out of these five studies, which suggests that further studies should be carried out to clarify whether or not these two devices are interchangeable for the measurement of ACD in normal eyes.
Moreover, Doors et al. measured ACD in phakic eyes following IOL implantation and Hashemi et al. and Kim et al. following laser refractive surgery. While in all three cases the authors observed statistically significant differences between Orbscan II and Pentacam, the mean difference was within clinically acceptable levels, except for the Doors et al. study. Thus, we can conclude that these are interchangeable after refractive surgery but not after phakic IOL implantation.

**Pentacam HR vs. Orbscan II**

Salouti et al. compared Pentacam HR with Orbscan II, obtaining significantly higher ACD values with Orbscan II, thus concluding that these devices should not be used interchangeably.

**Pentacam vs. Galilei**

Kiraly et al. compared the ACD values obtained with Pentacam and Galilei. They did not find any statistically significant differences between the two devices, thus concluding that Pentacam and Galilei can be employed interchangeably in clinical practice.

**Pentacam vs. Visante OCT**

Doors et al., Dinc et al., Kiraly et al., and O’Donnell et al. compared ACD measured with Pentacam and with Visante OCT. No statistically significant differences were found either by Kiraly et al. or by Yazici et al., thus concluding that these two devices can be used interchangeably in clinical practice. On the contrary, Door et al., Dinc et al. and O’Donnell et al. obtained significantly higher ACD values with Visante OCT than with Pentacam, thus concluding that these devices cannot be assumed to be interchangeable. However, since the mean difference obtained in these studies was within clinically acceptable limits, we believe that Pentacam and Visante OCT can be used interchangeably in normal eyes.

Doors et al. also included in their study a comparison of patients that had undergone phakic IOL implantation. In this group they also found statistically significant differences but the mean difference was again within clinical tolerance limits. Consequently, this study suggests that Pentacam and Visante OCT can be also used interchangeably to measure ACD in eyes that have undergone phakic IOL implantation.

**Pentacam vs. IOLMaster**

Eight studies have so far compared Pentacam with IOLMaster for the measurement of ACD, all reaching similar conclusions. Savant et al., Woodmass et al., and Kiraly et al. did not obtain any statistically significant differences between Pentacam and IOLMaster, and they concluded that these two devices may be used interchangeably in clinical practice.

On the other hand, Reuland et al., Utine et al., Dinc et al., Elbaz et al., and Su et al. observed statistically significant differences between Pentacam and IOLMaster, but they concluded that Pentacam and IOLMaster can be considered as interchangeable for use in clinical practice to calculate IOL power since the mean difference between these two devices lay within clinical tolerance levels. However, contradictory results were found for the estimation of IOL vaulting: while Reuland et al., Utine et al., Elbaz et al. and Su et al. obtained mean differences within clinical tolerance limits, Dinc et al. did not.

Moreover, Su et al. also compared Pentacam with IOLMaster in pseudophakic subjects. Since the authors did not obtain any statistically significant differences, we may conclude that Pentacam and IOLMaster can be used interchangeably for the measurement of ACD in pseudophakic eyes.

**Pentacam vs. Lenstar**

Only two studies so far (O’Donnell et al. and Huang et al.) have compared Pentacam with Lenstar for the measurement of ACD. Although O’Donnell et al. found statistically significant differences between these devices, as the mean difference was acceptable from a clinical point of view, it was concluded that they were interchangeable. However, Huang et al. did not find statistically significant differences between Pentacam and Lenstar. These studies, then, suggest that these two devices can be used interchangeably in clinical practice.

**Pentacam HR vs. Galilei**

Salouti et al. also studied the interchangeability between Pentacam HR and Galilei. They did not obtain significantly differences and concluded that these devices could be used interchangeably.

**Pentacam HR vs. IOLMaster**

Németh et al. studied the interchangeability of Pentacam HR and IOLMaster in phakic eyes. These authors did not find any statistically significant differences between these two devices. This study, then, suggests that Pentacam HR and IOLMaster can be used interchangeably in the clinical practice.

**DISCUSSION**

After these reviews, it can be concluded that the following devices can be used interchangeably with Pentacam or Pentacam HR in clinical practice: Pentacam-A-Scan for phakic patients, Pentacam-HR-A-Scan to calculate IOL power, Pentacam-Orbscan for phakic patients, Pentacam-Galilei for phakic patients, Pentacam-Visante OCT for
phakic patients and after phakic IOL implantation, Pentacam-IOLMaster\textsuperscript{6,10,11,15-18,20} to calculate IOL power and after pseudophakic IOL implantation, Pentacam-Lenstar\textsuperscript{25,26} for phakic patients, Pentacam HR-Galilei\textsuperscript{22} for phakic patients and Pentacam HR-IOLMaster\textsuperscript{26} for phakic patients.

The device pair whose interchangeability is still unclear is Pentacam-Orbscan II\textsuperscript{8,15,16,20,23,24} for phakic patients. Moreover, the device pairs that cannot be used interchangeably in clinical practice are Pentacam-A-Scan\textsuperscript{7,18} for pseudophakic patients, Pentacam-Orbscan II\textsuperscript{8} after phakic IOL implantation and Pentacam HR-Orbscan II\textsuperscript{23} for healthy subjects.

The present report clarifies the interchangeability of ACD measurements between Pentacam or Pentacam HR and other devices. However, discrepancies between studies may due to differences in the measurement method upon which each device is based. For instance, A-Scan and UBM rely on ultrasound; Orbscan and Orbscan II rely on scanning-slit topography; Pentacam, Pentacam HR and Galilei use Scheimpflug photography; Visante OCT uses low coherence interferometry; IOLMaster uses a lateral slit illumination and is based on partial coherence interferometry; whereas Lenstar measures ACD with optical biometry. Other sources of discrepancies may be the age group included in each study and the ability of the researcher to control the accommodation state during measurement in those studies that included young subjects.

Finally, further studies should be undertaken, aimed at studying the interchangeability of ACD measurements across different age groups, ocular conditions and interchangeability with other devices. It would also be interesting to define a relationship between the gold standard for ACD and the rest of the devices that are able to measure these distances. This would be useful for surgeons who could then know the ACD that a gold standard would yield without the need for having the device in the ophthalmology clinic. As a result, some post-surgical problems, such as those related to IOL power, could be avoided.

To conclude, Pentacam (for phakic eyes) and Pentacam HR (for cataractous eyes) can be used interchangeably with the two gold standards used to measure ACD (IOLMaster and A-Scan). This review also reveals that the interchangeability of the device depends on the patients’ ocular condition and this must be taken into consideration in clinical practice.

REFERENCES


First author:
Alberto Domínguez Vicent, MSc
Optometry Research Group (GIO), Valencia (Spain)