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eBOOK

Swept Source Biometry Results Similar to Partial Coherent Interferometry

BY FRED GEBHART

SYNOPSIS: Swept source optical coherence tomography (swept source OCT) is the latest technological advance in optical biometry. Swept source offers the potential for micron resolution measurements that could eventually simplify and improve intraocular lens power calculations. But there have been few head to head comparisons of swept source OCT and the current gold standard for biometry, partial coherent interferometry/Scheimpflug (PCI). In one of the largest direct comparisons to date, researchers found that OCT and PCI produced nearly identical and highly repeatable results across more than 200 eyes.

- There was no statistically significant difference in axial length or anterior chamber depth between OCT and PCI measurements.
- PCI/Scheimpflug measured a lower mean K value, -0.11D (p=0.01) compared to OCT.
- The mean calculated vector cylinder difference between Telecentric-based reading of the IOLMaster700 and for keratometry measurements of the AL-Scan was 0.39 D at 2o clockwise rotation when comparedto the more central optical zone,given that the AL-Scan offerstwo radii for keratometry at both 2.4 mm and 3.3 mm .
- Both methods showed similarly high repeatability and reproducibility.
- IOL power selection is similarly robust using PCI/Scheimpflug or OCT.

When treating cataract patients, calculating the intraocular lens power remains one of the most common challenges ophthalmologists face. IOL power calculation formulae are well known and highly precise, but the accuracy of the calculation, the clinical outcomes of the IOL and overall patient satisfaction with cataract surgery depend greatly on the accuracy of the anatomical measurements of the eye.

The history of ocular biometry has been a succession of more precise biometers using a succession of manual and automated technologies. Regardless of the device and the technology used, optical biometry provides anatomical measurements such as axial length, keratometry and anterior chamber depth.

Ultrasound biometry produces usable anatomical measurements, but ultrasound is a somewhat invasive procedure that requires direct contact with the cornea and the use of anesthetics, both of which can be somewhat uncomfortable for patients.

Ultrasound biometry also requires significant operator training and measurements are subject to significant variations between operators (interoperator variability) and between different measurements performed by the same operator (intraoperator variability). Simply changing the pressure of the ultrasound probe against the cornea can change the resulting measurements. Ultrasound biometry also requires adjustments in ultrasound speed for different media or optical conditions such as pseudophakic eyes and silicone oil.

The introduction of automated biometric instruments has dramatically reduced the risk of operator error and operator-based variability and greatly increased the accuracy and reliability of biometry. Noninvasive automated measurement devices have almost entirely replaced manual measurements in clinical practice, noted Joshua Frenkel, MD, resident in ophthalmology at Tulane University in New Orleans.

Dr. Frenkel was the lead author for a recent comparison of biometers conducted at the Bowie Vision Institute, a vision research collaboration in Bowie, MD. The results of the study suggest that biometry measurements using the prior generation of optical biometers, partial coherence interferometry plus corneal Scheimpflug-based analysis (PCI), are similar to measurements derived by the most recent generation of technology, swept source optical coherence tomography (OCT). In addition, both techniques appear to produce highly reproducible measurements with only minimal interoperator and intraoperator variability.

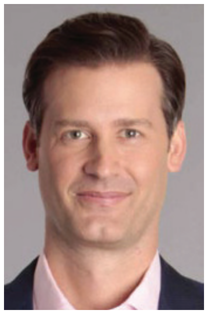
The Gold Standard

The current gold standard for optical biometry is partial coherence interferometry and corneal Scheimpflug-based analysis (PCI). The technique was introduced in the late 1990s and produced significantly improved results compared to ultrasound measurements.

PCI is an interferometry-based technique that uses infrared laser illumination (780 nm) to read the interference patterns between light reflected by the tear film and light reflected by the retinal pigmentary epithelium. These interference signals provide highly precise and highly repeatable measurements of the anterior length, the curvature of the anterior corneal surface, anterior chamber depth, the white-to-white iris diameter and other key anatomical measurements required to calculate the appropriate IOL power for each individual eye in cataract surgery.

"The latest generation of PCI instruments can produce highly accurate and highly reproducible biometric data in about ten seconds for each eye in clinical practice," Dr. Frenkel said. "You can routinely get all of the measurements for both eyes in under a minute. That's a significant factor when you are trying to run a busy practice in an efficient manner."

PCI eliminated two key sources of error inherent in ultrasound biometry, dependence on operator experience and variations in measurement due to differences technique between operators and between the same operator from one measurement to another.



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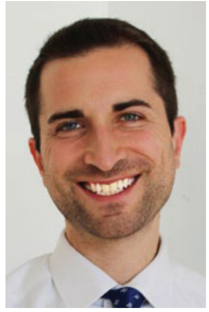

JoshFrenkel, M.D

The major limitation of PCI has been difficulty in accurately measuring anterior length and anterior chamber depth in eyes with densely opaque areas such as dense corneal leukomas and/or cataracts. For these eyes, it was still necessary to take manual ultrasound measurements.

The latest advance in biometry is swept source optical coherence tomography (OCT). OCT uses a tunable laser source to sequentially scan the eye using a sequence of narrow band wavelengths. Interference patterns from each wavelength are processed individually, then combined to produce a single high resolution image of the eye.

OCT provides a significantly improved signal-to-noise ratio compared to earlier methods. Each wavelength provides different tissue penetration. Combining the optimal images from each wavelength provides higher overall image quality and resolution down to the micron level throughout the eye.

The typical OCT image is a full-length longitudinal cut through the entire eye that shows unusual eye geometries such as tilt or decentralization of the crystalline lens.Utilizing multiple wavelengths provides improved visibility into more opaque media. OCT is reported to reduce the need for ultrasound by 90 percent compared to PCI, achieving an overall cataract penetration rate of 99 percent.

"Swept source is the cutting edge of biometry today," said senior author Jonathan D.Solomon, MD, Surgical/Refractive Director for Solomon Eye Associates and co-founder of the Bowie Vision Institute. "Swept source allows for an unrivaled degree of precision. And while swept source is likely to be the technology of the future, clinicians using PCI can rest assured that the measurements and the outcomes they are getting today are every bit as reliable and repeatable as those they can get using OCT. Our results show that PCI is just as accurate as swept source while remaining efficient in clinical practice."

Researchers at Bowie Vision Institute compared biometry from two different instruments, the IOLMaster 700 swept source OCT biometer (Zeiss) and the PCI/corneal Scheimpflug-based AL-Scan (NIDEK). The two instruments were used to determine axial length, anterior chamber depth, corneal power (in diopters (D) K), corneal astigmatism, central corneal thickness and lens thickness in a total of 220 cataractous eyes. The repeatability of OCT biometry was evaluated based on three sequential measurements captured for each patient.

There was no statistically significant difference in measurements of axial length or anterior chamber depth between OCT and PCI (R^2=0.9912 and R^2=0.9244 respectively), Dr. Frenkel reported. PCI consistently returned a lower mean K value of -0.11D (p=0.01) compared to OCT. The mean calculated vector cylinder difference between OCT and PCI biometry for keratometry measurements was 0.39D at 2o clockwise rotation when compared to the 2.4 mm optical zone.

Two Choices for Optimum Biometry

"Swept source is a new technology that allows you to make familiar measurements to calculate IOL power," Dr. Frenkel said. "I'm sure that while somewhere down the line, OCT will lead to some interesting new developments and applications, we did not find any clinically significant differences between the two technologies and devices."

The IOLMaster 700 takes 2,000 scans per second, producing highly repeatable and accurate results. The AL-Scan produces 360 data points for each mire ring, Dr. Frenkel noted, which produces similarly highly repeatable and accurate results. The two instruments produce statistically similar measurements and both produce highly reproducible measurements with minimal interoperator or intraoperator variation.

"Although OCT is the more advanced technology at this point, PCI is more the tried and true methodology with the greatest clinical experience," Dr. Solomon said. "PCI is the more tested and more efficient technology and the study demonstrates PCI is just as accurate as swept source for the key component related to IOL power calculation using current regression formulae."