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Review Article

Update and understanding of optical biometer

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ABSTRACT

With advances in technology that allow for more accurate measurement of ocular biometric characteristics and the availability of sophisticated methods for calculating intraocular lens (IOL) power, cataract surgery has evolved into a refractive operation. Patient expectations have been raised as a result of this, as well as free and simple access to information about the latest technology. After cataract surgery, there is a greater demand than ever for life without spectacles. Newer advances in optical biometry, such as swept-source optical coherence tomography, combined with the availability of highly accurate IOL power calculation formulae, including artificial intelligence-based formulae, have the potential to enable surgeons to achieve near-perfect outcomes in the majority of their patients. Understanding the benefits and limitations of currently available cutting-edge technologies and equations and applying them to the cataract surgical practice is required to hit the bull's eye in terms of goal refraction.

Keywords: Intraocular lens power, Optical biometry, Partial coherence interferometry, Optical lowcoherence reflectometry, Swept-source optical coherence tomography

INTRODUCTION

Whether the patient's eye is the normal, short, long or abnormal cornea, the surgeon's goal is to offer the greatest possible refractive outcome. To arrive at the precise intraocular lens (IOL) power prediction for each patient, accurate measurement of all ocular parameters is essential to get information about the full geometry of the eye.

Immersion A-scan, for axial length (AL) measurement in the late 20th century, was the gold standard; but partial coherence interferometry (PCI) biometry was first created by Austrian physicists Fercher and Roth, who performed the first *in vivo* AL measurement in 1986, shifting the scenario from immersion to optical biometry. In 1999, Carl Zeiss released the IOL master 500, the first commercially accessible optical biometer.[1]

THE FOLLOWING ARE THE KEY ADVANTAGES OF OPTICAL BIOMETRY OVER A SCAN

1. Optical biometry provides the most accurate measurement of AL since it measures from the corneal vertex to the photoreceptor, whereas A-scan measures from the corneal epithelium to the internal limiting membrane and has a correction factor of 200 microns on average[2]
2. Measurements are taken along the optical axis to the macula's centre in optical biometry. It calculates optical AL, as opposed to US biometry, which measures along anatomic/geometric axes and calculates anatomic AL. The visible axis and the geometric axis are not aligned. When it comes to estimating IOL power, it is the optical AL, not the anatomic AL, that matters[1,2]
3. Using shorter wavelengths, such as PCI/optical lowcoherence reflectometry (OLCR), allow for a more precise AL measurement. In comparison to 0.012 mm for optical AL, the accuracy of AL measurement with the US is roughly 0.10–0.12 mm[3]
4. Pseudophakic and aphakic eyes, as well as eyes with phakic IOLs, can have accurate biometry done. The kind of IOL material has less of an impact on AL measurement[4-7]
5. When compared to A-scan biometry, optical biometry provides more precise measurements in myopic eyes with staphyloma, youngsters and silicone oil-filled eyes (no need for velocity conversion equation).[8-11]

THE VALUE OF EXACT MEASUREMENT (OPTICAL BIOMETRY)

Optical technology must provide accuracy and consistency when measuring ocular characteristics to obtain the inputs for IOL power calculations today. The majority of published

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reports on these technologies place a strong emphasis on reproducibility and accuracy.

In general, when choosing biometric equipment, we must examine how accurate it measures the anterior and posterior corneal curvatures, AL, anterior chamber depth (ACD) and lens thickness (LT). These are the four key variables that are utilised to calculate the implantable IOL's power.

The anterior surface of the cornea can be measured using a variety of technologies, including reflection-based approaches such as keratometry and corneal topography, Scheimpflug imaging and anterior segment OCT. Each technology has its own set of advantages and disadvantages. Reflection-based methods can measure with great precision, but they have limits when it comes to obtaining information on the posterior corneal surface and even ultrastructural information from the cornea. Scheimpflug measures and anterior segment OCT, on the other hand, provide this information. The precision of measurement is currently a constraint of these two technologies due to motion artefacts related to data gathering.[12]

Precision AL measurements are necessary for addition to correct corneal curvature measurements. Optical coherence methods are used in commercially available instruments to determine AL. Three aspects influence accuracy in this case: (1) The signal-to-noise ratio for peak detection; (2) eye motion during an AL scan; and (3) the fluctuation of the ocular media's refractive index. The signal-to-noise ratio and scanning speed are frequently connected. Faster scanning eliminates eye motion abnormalities, but it can potentially lower signals, especially in dense cataracts.

The unknown effective refractive index of the crystalline lens is an unsolved challenge in currently accessible technology. To calculate the geometric AL from the optical coherence signal, the most systems use an ultrasonic equivalent. The accuracy of the AL measurement is harmed since the refractive index varies significantly from eye to eye depending on cataract grade.[13]

ACD and LT have been established as pre-operative characteristics that can aid in the accurate prediction of IOL position. As a result, ocular biometry should be able to reliably and correctly quantify these characteristics.

AN OVERVIEW OF OCULAR BIOMETRY DEVICES

Today's optical biometers employ one of the following technologies:

1. PCI
2. OLCR
3. Swept-source optical coherence tomography (SS-OCT).

PCI

This technology was created by Fetcher and Roth in 1986. In contrast to an ultrasonic A-scan, PCI uses infrared light. This light is reflected by tissue surfaces with different refractive indices. The ocular distances are then measured using interferometric techniques.[14]

A dual coaxial beam interferometer is used to reduce the influence of longitudinal eye movements. Two light beams are inserted into the eye. The mutual temporal delay of these beams is equivalent to twice the interferometer's arm length difference. Tissue contacts reflect this light, resulting in a PCI signal. AL is calculated using light reflected from the anterior corneal surface and the retinal pigment epithelium.[14]
Examples of devices using PCI technology are –
IOL Master 500 from Carl Zeiss,
AL-Scan from Nidek,
Pentacam AXL from Oculus.

OLCR

The Michealson interferometer principle is used by OLCR. A superluminescent diode produces low-coherence infrared light, which is split into two beams by a coupler. One beam is aimed toward a scanning reference mirror, while the other is inserted into the eye. Light is reflected by tissue interfaces. A detector detects the interference pattern generated by the coaxially travelling emitted and reflected light. Scanning the reference beam determines the precise spot from which the light was reflected from within the eye.[15]

Examples of devices using OLCR technology are –

Lenstar LS900 (Haag-Streit),

Aladdin (Topcon),

Galilei G6 (Zeimer).

SS-OCT

A superluminescent diode is not used in SS-OCT machines. Instead, a fast-sweeping laser is used as the source. The reference mirror remains unmoved. The collected interference signal is then transformed into Fourier form.[16,17]
Examples of devices using SS-OCT technology are –
The IOL Master 700 (Carl Zeiss),
Argos (Movu),
O.A 2000 (Tomey)
Eyestar 900 (Haag-Streit).

OPTICAL BIOMETER

IOL Master 500

Carl Zeiss produced the first commercially available optical biometer.

The source for the IOL Master 500 [Figure 1][18] is a 780 nm infrared laser. It is based on the PCI principle. It can measure AL to a precision of 0.02 mm, 5 times better than an immersion ultrasound biometer.[19]

Optical biometry uses a different set of IOL A-constants than ultrasonic biometry.

In addition to AL, the IOL Master 500 measures – Keratometry (K), ACD and horizontal white-to-white (WTW) distance (AL).

The ACD is measured using a projected slit.

SRK II, SRK-T, Haigis, Hoffer Q, Holladay-1, Haigis–L and Holladay 2 are among the equations accessible on board the IOL Master 500.

In eyes with dense corneal or lenticular opacity, the IOL Master 500 may be unable to reliably measure AL. The adoption of technology in new version 5.0 soft wear that took the average of numerous scans increased the accuracy of scans in opaque material to some extent. This programme enables the composite scan of many optical scans, resulting in an improved capacity to perform biometry through dense cataracts.[20]

ALscan

The AL-Scan [Figure 2][21] from Nidek is a PCI-based biometer that measures AL using an 830 nm IR laser diode.

It includes '3D auto-tracking,' which tracks the patient's eye movements in three dimensions: X, Y and Z. When the device detects proper alignment, it uses the 'autoshot' feature to take the scan.

AL, ACD, WTW, pupil size and central corneal thickness (CCT) can all be measured using it (CCT). CCT and ACD are measured using Scheimpflug imaging (a Scheimpflug system images the anterior segment with a camera perpendicular to a slit beam, thus creating an optical section of cornea and lens).[22]

Keratometry and corneal topography are performed using rings reflected from the anterior corneal surface.

Aberrations can be evaluated using topography and K with double mire rings. It has a 36-point K rating.

Toric lens assist images can also be captured with the AL-scan for digitally designating the axis of toric IOL installation.

An ultrasound pachymeter and an A-scan are also included with the AL-scan.

This biometer includes all commonly used IOL calculation formulae.

PentacamAXL

The oculus pentacam-AXL [Figure 3][21] is a hybrid of a PCI-based optical biometer and an elevation-based tomographer. Corneal tomography is performed with a revolving Scheimpflug camera and the AL is determined using PCI technology.

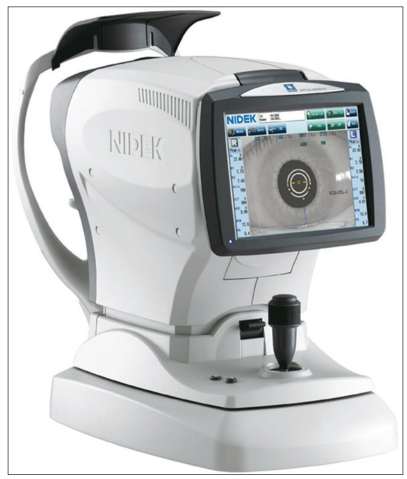

Figure 2: AL Scan.[21]

Figure 1: IOL Master 500.[18]

Figure 3: Pentacam AXL.[21]

The ability to measure posterior corneal astigmatism is a feature of the Pentacam AXL that provides it with an advantage when it comes to toric IOL planning.[23]

It is also useful for determining IOL power in eyes that have had corneal refractive surgery.

The device also includes wavefront analysis capabilities.

The device has the most often used IOL power calculating equations.[24]

Lenstar LS900

The Lenstar LS-900 [Figure 4][25] measures ocular distances with OLCR technology.

The AL, ACD and LT are measured using a low-coherent beam of light with an 820 nm wavelength produced by a superluminescent diode.

A dual-zone keratometry (at 1.65 and 2.3 mm) and T cone topography are performed using 32 points positioned close together (allows true Placido topography of the central cornea).

The Lenstar LS-900 supports all recent IOL calculation formulae, including Holladay IOL Consultant Professional, the Barrett Suite, Hill-radial basis function (RBF), Masket, Modified Masket and Shammas No-history. Oculix and Olsen formulas are also available through a separate software interface.[26]

Aladdin HW3.0

The Topcon Alladdin HW [Figure 5][27] 3.0 combines a reflection-based topographer with an optical biometer.

OLCR technology is used to calculate AL.

Keratometry can be done at three different zones: Three, five and seven millimetres. To perform anterior corneal topography, 24 Placido rings are used. The device incorporates the company's real corneal radii technology, which collects roughly 1000 data points at a 3-mm diameter and measures the corneal radii as accurately and consistently as possible.

Zernicke wavefront analysis can be used to assess higher-order aberrations.

With mesopic, photopic and dynamic pupillometry capabilities, the pupil response can be measured during the Placido examination.

AL, keratometry, topography, ACD, pupillometry, WTW distance, CCT, and LT are all available in one acquisition on the Aladdin LT.

The Alladdin HW 3.0 includes the most common spherical and toric IOL power calculation equations. Traditional IOL power calculation formulas including SRK II, SRK/T, Holladay 1 and Haigis, as well as post-refractive surgery formulas such as Camellin-Calossi and Shammas no-history are included in the software. The Aladdin LT also contains a toric IOL rotation simulator and generic toric IOL calculating capabilities.[28,29]

Galilei G6

OLCR optical biometry [Figure 6][30], dual Scheimpflug imaging and Placido disc topography are all included in the Galilei G6.

It analyses anterior and posterior corneal power, axis and wavefront analyses, which help us for cataract and refractive surgery planning.

It offers three-dimensional (3D) anterior chamber analysis and high-definition pachymetry.

Figure 4: Lenstar LS 900.[25]

Figure 5: Aladdin HW3.0.[27]

Shammas No-History, Barrett Universal and Barrett True-K Toric calculators are among the newest IOL power formulas included in the study.

The Galilei G6 also has access to Okulix and PhacoOptics, which are ray tracing IOL power calculation algorithms.[31]

In addition to cataract surgery, the device can do thorough topographic screening of refractive surgery candidates, including keratoconus screening, and it is useful in planning for corneal implants as well as keratoplasty patient planning and follow-up.[32]

Using the Asphericity Asymmetry Index, the Galilei G6 provides a more morphologic method for identifying subclinical keratoconus at its earliest stages (AAI). A distinctive characteristic of ocular biometry is the combination of a morphologic approach (decision tree) and a biomechanical method (PTA report) that can improve the sensitivity of the detection of corneas at risk for ectasia.[33]

IOL Master 700

The swept-source-OCT technique, which offers a full-length OCT image of the eye, exhibiting anatomic details in a longitudinal cut through the length of the organ, was initially used in the IOLMASTER 700 [Figure7][34] optical biometer. It enables the detection of unique ocular geometrical traits such as crystalline lens tilt or decentration.

The OCT image also serves as a fixation check: If the image shows the foveal pit, the patient has been properly fixed.

Telecentric keratometry, a distance-independent method that provides reliable measurements even in restless patients, is also available on the device. It can also use SS-OCT technology to quantify posterior corneal curvature, resulting in a new metric called total keratometry.[35,36]

The biometric characteristics required for modern IOL power calculation methods, such as CCT, LT, AL and ACD, are included in anatomic measurements. Measurement is also possible in eyes with extensive cataracts and other media opacities, where OLCR or PCI-based optical biometry was previously impossible.

Other IOL power calculation equations (SRK/T formula, Hoffer Q, Holladay 1 and 2 and Barrett suit) are included in the programme, as well as the 'Haigis Suite' (which comprises Haigis, Haigis T for torics and Haigis L for post-refractive surgery eyes).[37]

The Zeiss Cataract Suite markerless, which also comprises the IOLMaster 700, Callisto eye and OPMI Lumera line of microscopes, may use the IOLMaster 700 (all devices by Carl Zeiss Meditec).

Argos

The Argos [Figure 8][38] optical biometer is based on coherent optical interferometry and tomography using a 1-m swept-source beam with lateral scanning.

A near-infrared swept laser is scanned across the patient's eye with swept-source technology. As light returns from boundary layers, the device's software creates an accurate simulation of the ocular physiology. Real-time 2-D imaging of the eye is possible during biometer alignment thanks to quick image reconstruction methods.

The illumination of a ring of 16 infrared LEDs produces keratometry (K) values. Corneal curvature data are created by combining the reflected picture from the LEDs with the OCT signal. AL, CCT, ACD, LT, K values, pupil size and toric axis are among the parameters examined.

Argos' major benefit is its ability to scan through highly extensive cataracts because of an 'Enhanced Retinal Visualisation' mode that boosts the retinal area's imaging sensitivity by 100 times (without increasing laser power).

The Argos employs a proprietary sweeping laser source that is optimised for deep imaging (>50 mm) with a line rate of

Figure 6: Galilei G6.[30]

Figure 7: IOL Master 700.[34]

3000 lines/SA. The Argos also has an 'Analysis mode' that allows surgeons to double-check the results.[38]

OA2000 (Tomey)

Based on Fourier-domain technology and Placido-disc-based corneal topography, Tomey's OA-2000 [Figure 9][39] optical biometer enables non-contact, non-invasive, automatic assessment of AL, ACD, LT, and CCT.

Placido-disc corneal topography is also included in the OA-2000 to quantify the radius of corneal curvature and define corneal form. The topographer measures not only the normal 3-mm optical zone but also 2.5 and 2 mm optical zones at the same time. It also generates a topography map to aid in detecting irregular astigmatism.

In one rapid shot, up to seven sets of measurement data, including CCT, LT, WTW and ACD, as well as AL and keratometry, can be collected. The device can use this information to execute a sequence of computations throughout the patient's care, beginning with the pre-operative examination and progressing through IOL power calculation, post-surgery data storage, surgeon A-constant optimization and statistical analysis.

Figure 8: Argos.[38]

AL and CCT measurements can be taken with the AL-4000 handheld ultrasound biometer (Tomey), which communicates with the OA-2000 through Bluetooth technology in rare cases of very developed cataracts.

SRK-II, SRK/T, Haigis, Holladay, Hoffer Q and two formulas for eyes with surgically corrected corneal refractive power are among the nine formulas included in the OA-2000's IOL power calculation function. Oculix and Olcen formulae can be obtained with the addition of the software of Ray tracing.[40]

Eyestar 900

In October 2017, a new device based on SS-OCT was released. The EyeSuite software on the device offers elevation-based topography maps of both the front and back of the cornea, as well as biometry data from the cornea to the retina.

Eyestar 900 [Figure 10][41] produces 2D and 3D pictures of the anterior segment and crystalline lens. The data collection technique is painless and quick, ensuring patient comfort. Hill-RBF and Barrett Universal 2 are two of the most recent IOL power calculation equations included in the device.

The PCI, OCLR and SS-OCT biometry devices have been compared in several investigations.[42] The majority of researchers have found a strong association between PCI, OCLR and SSOCT biometry readings.[31,43]

Intraoperative wavefront aberrometry

Intraoperative wavefront aberrometry is one of the most recent advancements in the field of cataract surgery. It can

Figure 9: OA 2000.[39]

Figure 10: Eyestar.[41]

take aphakic and pseudophakic refractive measurements on the eye that is being operated on in the operating room, providing real-time intra-operative refractive data.

This allows the surgeon to confirm or update the IOL power (as determined by pre-operative biometry), optimise the lens position and customise arcuate corneal incisions to the eye's astigmatic needs.[44,45]

Optiwave refractive analysis system (ORA)

WaveTec Vision Systems, Inc.'s Orange wavefront aberrometry device was the first commercially available intra-operative wavefront aberrometer. The ORA [Figure 11][46] system has now taken its place.

ORA makes use of infrared light and Talbot Moire interferometry, a technique in which wavefronts diffract across two gratings at a specified angle and distance to form a fringe pattern.[47] This fringe pattern is then examined for sphere, cylinder and axis information, which is used to advise optimal IOL selection (including premium IOLs) and placement. It plays a unique role in the implantation of toric IOLs.

ORA is connected to a surgical microscope in the operating room, and aphakic and pseudophakic refractions are done. It takes less than a minute to take 40 measurements. The intra-operative aberrometer provides unprecedented precision during cataract surgery by providing real-time data to surgeons.

ORA has transformed premium cataract surgery, with some surgeons employing it in all of their toric, presbyopia-correcting IOLs, as well as a guide for intra-operative astigmatic keratotomy.

The ORA SYSTEM detects entire ocular refraction during cataract surgery when it matters most to assist improve outcomes for all patients, to minimise refractive surprises and power real-time, in-procedure modifications. It saves new data from each procedure in its unrivalled AnalyzORTM database, which currently has over 2 million cases of optimal data at the surgeon's fingertips. This repository is reoptimised periodically to ensure that the ORA SYSTEM's refractive outcomes improve over time.

Philips Health Suite powers Alcon's cloud-based connection between the ORA, AnalyzOR and ARGOS biometer, allowing for a streamlined approach to practise data management with automatic data exchange from the clinic to the operating room, all backed by Windows 10 software and security improvements.

Intra-operative Aberrometry Versus Pre-operative Biometry for IOL Power Selection After Radial Keratotomy: A Prospective Study by Sabastian Xavier Curado The ORA aberrometer performed similarly to the Barrett True-K formula and all other established formulas in eyes with prior radial keratotomy surgery, with no significant difference between median absolute error and mean absolute error.[48]

Holos

Clarity's Holos [Figure 12][49] IntraOp is a second intra-operative aberrometer. To measure the magnitude of wavefront displacement, it employs a fast-rotating microelectromechanical mirror and a quad detector. Holos, like the ORA, collects optical wavefront and refraction data intraoperatively to validate the pre-planned IOL power and to aid in the selection of incision size and position to correct astigmatism.[50] At any given time, up to 90 measurements are taken. It is connected to an operating microscope, just like the ORA, for intra-operative refractive measurements.

The aberrometer on the HOLOS instrument is a highly advanced gadget that was created expressly for this purpose,

Figure 11: ORA.[46]

Figure 12: HOLOS.[49]

which is one of its advantages. The data are continuously filtered by measurement qualifiers by the HOLOS aberrometer, which is fast and accurate. That is to say before a measurement is presented on the screen, it must first pass muster. As a result, the HOLOS aberrometer has a 40-D dynamic range and is accurate within 0.25 D at the corneal plane. A separate person in the OR is not required to operate the system because the data are continuously shown.

Comparison of ORA and HOLOS

ORA intra-operative aberrometry take several snapshots readings before making an IOL power selection, to feel certain that the measurements are correct, the HOLOS system will uniquely provide the data. It may take several minutes to complete this task. The HOLOS system continuously takes roughly 90 readings per second and qualifies each one so that only qualified readings are used in IOL computations. Instead of displaying the results of the surgeon's photographs, the HOLOS will provide a frequency histogram that displays how often a certain IOL power is advised by the formula in real-time.

The focal point of HOLOS surgery is retained at the iris plane or wherever the surgeon is working. The surgeon does not have to readjust the scope to achieve qualified readings because the data are constantly generated and certified. To get a reading, you do not have to alter the focus, switch off the microscope light or raise the system to a set height above the cornea as you do with ORA.[46] The focus of the HOLOS[49] system corresponds to the focus in the microscope. This improves your efficiency in OR.

The HOLOS system's optics are designed to take less light away from the microscope's optical path than the ORA.

ORA's AnalyzOR databank has 2 million instances. ORA has optimised a wide range of lens model outcomes, with Barrett Universal II and Rx and all other formulas. HOLOS does not have the benefit of combining data from thousands of cases at first, as the ORA system, so came up with the HOLO-Barrett IOL formula, as its new set database.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Drexler W, Findl O, Menapace R, Rainer G, Vass C, Hitzenberger CK, *et al.* Partial coherence interferometry: A novel approach to biometry in cataract surgery. Am J Ophthalmol 1998;126:524-34.
2. Németh J, Fekete O, Pesztenlehrer N. Optical and ultrasound measurement of axial length and anterior chamber depth for intraocular lens power calculation. J Cataract Refract Surg 2003;29:85-8.
3. Holladay JT. Ultrasound and optical biometry. Cataract Refract Surg Today Europe 2009 p. 18-9.
4. Haigis W. Pseudophakic correction factors for optical biometry. Graefes Arch Clin Exp Ophthalmol 2001;239:589-98.
5. Khurana AK. Intraocular lenses: Optical aspects and power calculation. In: Theory and Practice of Optics and Refraction. 2nd ed., Ch. 9. Amsterdam, Netherlands: Elsevier Publications; 2008.
6. Naeser K, Naeser A, Boberg-Ans J, Bargum R. Axial length following implantation of posterior chamber lenses. J Cataract Refract Surg 1989;15:673-5.
7. Pitault G, Leboeuf C, Leroux Les Jardins S, Auclin F, Chong-Sit D, Baudouin C, *et al.* Optical biometry of eyes corrected by phakic intraocular lenses. J Fr Ophtalmol 2005;28:1052-7.
8. Ikuno Y, Tano Y. Retinal and choroidal biometry in highly myopic eyes with spectral-domain optical coherence tomography. Invest Ophthalmol Vis Sci 2009;50:3876-80.
9. Yasuno Y, Miura M, Kawana K, Makita S, Sato M, Okamoto F, *et al.* Visualization of sub-retinal pigment epithelium morphologies of exudative macular diseases by high-penetration optical coherence tomography. Invest Ophthalmol Vis Sci 2009;50:405-13.
10. Pierre Kahn V, Quoc EB, Chauvaud D, Renard G. Axial length measurement in silicone oil filled eyes using optical biometry. Invest Ophthalmol Vis Sci 2005;46:5543.
11. Wilson ME, Trivedi RH. Axial length measurement techniques in pediatric eyes with cataract. Saudi J Ophthalmol 2012;26:13-7.
12. Lee YW, Choi CY, Yoon GY. Comparison of dual rotating Scheimpflug-Placido, swept-source optical coherence tomography, and placido-scanning-slit systems. J Cataract Refract Surg 2015;41:1018-29.
13. Mylonas G, Sacu S, Buehl W, Ritter M, Georgopoulos M, Schmidt-Erfurth U. Performance of three biometry devices in patients with different grades of age-related cataract. Acta Ophthalmol 2011;89:e237-41.
14. Findl O, Drexler W, Menapace R, Kiss B, Hitzenberger CK, Fercher AF. Optical biometry in cataract surgery. Mod Cataract Surg 2002;34:131-40.
15. Schmid GF. Axial and peripheral eye length measured with optical low coherence reflectometry. J Biomed Opt 2003;8:655-62.
16. Srivannaboon S, Chirapapaisan C, Chonpimai P, Loket S. Clinical comparison of a new swept-source optical coherence tomography-based optical biometer and a time-domain optical coherence tomography-based optical biometer. J Cataract Refract Surg 2015;41:2224-32.
17. Leitgeb R, Hitzenberger C, Fercher A. Performance of Fourier domain vs. time domain optical coherence tomography. Opt

Express 2003;11:889-94.
18. Carl Zeiss Meditec AG. IOLMaster 500. Available from: http://www.zeiss.com/meditec/en_us/products---solutions/ophthalmology-optometry/cataract/diagnostics/optical-biometry/iolmaster-500.html. [Last accessed on 2022 Feb 01].
19. Hill W, Angeles R, Otani T. Evaluation of a new IOL Master algorithm to measure axial length. J Cataract Refract Surg 2008;34:920-4.
20. Epitropoulos A. Axial length measurement acquisition rates of two optical biometers in cataractous eyes. Clin Ophthalmol 2014;8:1369-76.
21. Nidek Co., Ltd. Optical Biometer AL-Scan. Operator's Manual. Japan: Nidek Co., Ltd.; 2012. p. 220.
22. Aktas S, Aktas H, Tetikoglu M, Sagdk HM, Özcura F. Refractive results using a new optical biometry device: Comparison with ultrasound biometry data. Medicine (Baltimore) 2015;94:e2169.
23. Piñero DP, Alió JL, Alesón A, Escaf M, Miranda M. Pentacam posterior and anterior corneal aberrations in normal and keratoconic eyes. Clin Exp Optom 2009;92:297-303.
24. Karunaratne N. Comparison of the Pentacam equivalent keratometry measurement in intraocular lens power calculations. Clin Exp Ophthalmol 2013;41:825-34.
25. Haag-Streit Diagnostics. Lenstar LS 900. Available from: http://www.haagstreit.com/products/biometry/lenstarls900r.html. [Last accessed on 2022 Feb 01].
26. Lenstar LS 900. Haag-Streit. Available from: http://www.haag-streit.com/products/biometry/lenstar-ls-900r.html [Last accessed on 2015 Jun 04].
27. Aladdin, Biometer (Brochure). Topcon Europe Medical Website. Available from: http://www.topconmedical.eu/eu/products/191aladdinbiometer.html#downloads. [Last accessed on 2022 Feb 01].
28. Hoffer KJ, Shammas HJ, Savini G, Huang J. Multicenterstudy of optical low-coherence interferometry and partial-coherence interferometry optical biometers with patients from the United States and China. J Cataract Refract Surg 2016;42:62-7.
29. Mandal P, Berrow EJ, Naroo SA, Wolffsohn JS, Uthoff D, Holland D, *et al*. Validity and repeatability of the Aladdin ocular biometer. Br J Ophthalmol 2014;98:256-8.
30. Galilei G6 Lens Professional. Ziemer Ophthalmic Systems AG Website. Available from: http://www.galilei.ziemergroup.com/key-features-g6.html. [Last accessed on 2022 Feb 01].
31. Ventura BV, Ventura MC, Wang L, Koch DD, Weikert MP. Comparison of biometry and intraocular lens power calculation performed by a new optical biometry device and a reference biometer. J Cataract Refract Surg 2017;43:74-9.
32. Smadja D, Santhiago MR, Mello GR, Krueger RR, Colin J, Touboul D. Influence of the reference surface shape for discriminating between normal corneas, subclinical keratoconus, and keratoconus. J Refract Surg 2013;29:274-81.
33. Smadja D, Touboul D, Cohen A, Doveh E, Santhiago MR, Mello GR, *et al.* Detection of subclinical keratoconus using an automated decision tree classification. Am J Ophthalmol 2013;156:237-46.
34. The New IOLMaster 700. Carl Zeiss Website. Available from: http://www.zeiss.com/meditec/en_de/products---solutions/ophthalmology-optometry/cataract/diagnostics/optical-biometry/iolmaster-700.html#highlight. [Last accessed on 2022 Feb 01].
35. Savini G, Næser K. An analysis of the factors influencing the residual refractive astigmatism after cataract surgery with toric intraocular lenses. Invest Ophthalmol Vis Sci 2015;56:827-35.
36. Preussner PR, Hoffmann P, Wahl J. Impact of posterior corneal surface on toric intraocular lens (IOL) calculation. Curr Eye Res 2015;40:809-14.
37. Shammas HJ, Ortiz S, Shammas MC, Kim SH, Chong C. Biometry measurements using a new large-coherence-length swept-source optical coherence tomographer. J Cataract Refract Surg 2016;42:50-61.
38. Argos. Movu. Available from: http://www.movu-inc.com/product [Last accessed on 2015 Jun 15].
39. Tomey Optical Biometer. Available from: http://www.tomey.de>docs>OA-2000_Tips_2017. [Last accessed on 2022 Feb 01].
40. OA-2000 Optical Biometer. Tomey GmbH. Available from: http://www.tomey.de/en/products/optical-biometry/oa-2000 [Last accessed on 2015 Jun 11].
41. Eyestar 900-the Comprehensive OCT Eye Analyser-Haag-Streit. Available from: https://www.haagstreit.com>eyestar900. [Last accessed on 2022 Feb 01].
42. Nazm N, Chakrabarti A. Update on optical biometry and intraocular lens power calculation. TNOA J Ophthalmic Sci Res 2017;55:196-210.
43. Kunert KS, Peter M, Blum M, Haigis W, Sekundo W, Schütze J, *et al*. Repeatability and agreement in optical biometry of a new swept-source optical coherence tomography-based biometer versus partial coherence interferometry and optical low-coherence reflectometry. J Cataract Refract Surg 2016;42:76-83.
44. Ianchulev T, Salz J, Hoffer K, Albini T, Hsu H, Labree L, *et al*. Intraoperative optical refractive biometry for intraocular lens power estimation without axial length and keratometry measurements. J Cataract Refract Surg 2005;31:1530-6.
45. Masket S, Fram NR. Achieving Targeted Refractive Outcomes in Cataract Surgery with Intraoperative Wavefront Aberrometer; and Comparison of IOL Power Calculations in Post-LASIK Eyes Having Cataract Surgery Using Multiple Formulas, OCT, and Intraoperative Aberrometry. San Francisco: ASCRS Symposium on Cataract, IOL, and Refractive Surgery; 2013.
46. ORA LASER Abberrometer-Colvard-Kandavel Eye Center. Available from: https://www.colvardvision.com. [Last accessed on 2022 Feb 01].
47. Roach L. Intraoperative Wavefront Aberrometry: Wave of the Future? EyeNet Magazine. American Academy of Ophthalmology; 2017. Available from: https://www.aao.org/eyenet/article/intraoperativewavefront-aberrometry-wave-of-future. [Last accessed on 2022 Feb 01].
48. Curado SX, Hida WT, Vilar C, Ordones VL, Chaves M, Tzelikis PF. Intraoperative aberrometry versus preoperative biometry for IOL power selection after radial keratotomy: A prospective study. J Refract Surg 1995;35:656-61.
49. Available from: https://www.ophthalmologymanagement.com/issues/2016/june-2016/spotlight-on-technology-amp;-technique. [Last accessed on 2022 Feb 01].
50. Hill W. Intraoperative Aberrometer Evolves with New Standard for Accuracy. Ophthalmology Times; 2015. Available from:

http://www.ophthalmologytimes.modernmedicine.com/ophthalmologytimes/news/intraoperative-aberrometer-evolves-new-standard-accuracy. [Last accessed on 2022 Feb 01].

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