ARTICLE

Repeatability and comparability of corneal power and corneal astigmatism obtained from a point-source color light–emitting diode topographer, a Placido-based corneal topographer, and a low-coherence reflectometer

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PURPOSE: To assess the repeatability and agreement of corneal power and astigmatism obtained from the Cassini point-source color light–emitting diode (LED) topographer, Humphrey Atlas 9000 Placido–based corneal topographer, and Lenstar LS-900 low-coherence reflectometer in normal eyes.

SETTING: Cullen Eye Institute, Baylor College of Medicine, Houston, Texas, USA.

DESIGN: Evaluation of diagnostic test or technology.

METHODS: Consecutively enrolled patients with normal corneas were enrolled. Three sets of measurements were obtained using the color-LED topographer, the Placido topographer, and the reflectometer. Vector analysis was used in the astigmatism analysis. The repeatability was evaluated using the within-subject standard deviation, coefficient of variation (CoV), and intraclass correlation coefficient (ICC). Agreement was verified using Bland-Altman plots. The paired Student *t* test was used to assess statistical significance.

RESULTS: Thirty-two eyes (32 patients) were evaluated. All devices provided highly repeatable corneal power and astigmatism measurements (ICC > 0.9) except for the Placido topographer with regard to J45 (ICC = 0.721). The color-LED topographer and the reflectometer obtained similar mean values of corneal power, astigmatism magnitude, J0, and J45 ($P > .05$), which was also true when comparing the color-LED topographer and the Placido topographer, except for the mean corneal power ($P = .0007$). The Bland-Altman plots showed a wide data spread for all analyzed variables.

CONCLUSIONS: The color-LED topographer provided highly repeatable corneal power and astigmatism measurements. Even though it obtained values similar to those of the reflectometer and the Placido topographer, the wide data spread discourages their interchangeable use to assess corneal power and astigmatism.

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In the past 3 decades, advances in cataract surgery have dramatically improved patients' outcomes, increasing their expectations. To achieve optimum visual results, reproducible and accurate measurements of corneal power and astigmatism are crucial.[1] Currently, these parameters can be measured using different devices, such as manual keratometers, automated keratometers, Placido-based corneal topographers, scanning-slit corneal topographers, Scheimpflug image–based topographers, and low-coherence reflectometers.[2]

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Even though many devices are available, there is no specific gold standard to determine the clinical accuracy of corneal curvature measurements. Thus, the comparison of repeatability is a good method to help establish which instruments perform better. Furthermore, agreement is a way of evaluating the exchangeability of measurements obtained by different machines and can be an indirect indicator of accuracy.[3] Several studies have previously investigated the repeatability and the agreement of the above-mentioned devices, encouraging their use to assess corneal power and astigmatism for cataract surgery planning.[3–9]

The Cassini (i-Optics Corp.) is a new corneal topographer and the first commercially available topographer that uses point-source color light–emitting diode (LED) technology. It obtains a corneal image based on the reflection of individual points of light.[10] Knowledge of the repeatability and comparability of new devices is essential to assess their clinical performance. Therefore, the purpose of the present study was to evaluate the comparability and the repeatability of corneal power and corneal astigmatism measurements obtained by the color LED topographer, a Placido-based corneal topographer, and a low-coherence reflectometer in healthy eyes.

SUBJECTS AND METHODS

This prospective observational case series was approved by the Institutional Review Board of the Baylor College of Medicine and followed the tenets of the Declaration of Helsinki. Patients who came to the Cullen Eye Institute, Department of Ophthalmology, Baylor College of Medicine, to have cataract surgery performed by the same surgeon (D.D.K.) between August 2013 and April 2014 were eligible to participate. Subjects who had a history of ocular trauma, ocular surgeries, corneal or other ocular diseases that could affect outcomes, soft contact lens wear within 2 weeks of the measurements, or rigid gas-permeable contact lens wear within 4 weeks of the measurements were excluded. Written informed consent was obtained from each subject before inclusion in the study.

Three measurements of acceptable quality were obtained by the same examiner (B.V.) for each of the following 3 devices: the Cassini (version 1.0) color-LED topographer, the Humphrey Atlas 9000 corneal topographer (version 3.0.0.39, Carl Zeiss Meditec AG), and the Lenstar LS-900 reflectometer (version 3.0.2, Haag-Streit AG). The measurements were considered acceptable if they satisfied the quality criteria for each individual device. The rooms were kept in semidarkness to facilitate fixation. The subjects were asked to sit back in between measurements, careful alignment was verified before each examination, and the subjects were instructed to blink completely just before each measurement. For each participant, all measurements were performed within a 30-minute period, and the first eye that was to have cataract surgery was selected for the study.

All 3 devices use an adjusted refractive index of 1.3375 to convert anterior corneal radius of curvature measurements to total corneal power in diopters (D), and each has specific characteristics:

The color-LED topographer obtains its data based on the analysis of the specular reflection of approximately 700 color LEDs consisting of red, yellow, and green lights. These LEDs are arranged in a specific pattern to ensure a one-to-one correspondence between the source and the image points, which potentially decreases source-image mismatch and artifacts caused by shadow. This device evaluates the keratometry (K) value in the central 3.0 mm zone.

The Placido topographer acquires data based on 22 Placido rings, with each ring containing 180 datapoints with an angular resolution of 2 degrees. This device provides simulated K values along the steepest and flattest meridians at the 3.0 mm annular ring.

The reflectometer is a low-coherence reflectometer that calculates K values based on an array of 32-point reflections projected off the anterior corneal surface. The points are arranged in 2 rings with 16 points each at diameters of approximately 1.65 mm and 2.3 mm.

Statistical Analysis

The statistical analysis was performed using SPSS for Windows (version 15.0, SPSS Inc.) and Office Excel (Microsoft Corp.). The results of the qualitative variables were expressed by their absolute and relative frequencies. The results of the quantitative variables were expressed by their minimum and maximum values, mean, and standard deviations (SD). Normality was checked using the Kolmogorov-Smirnov test.

The mean corneal power was calculated for each measurement on each device as the arithmetic average of the anterior corneal steep K and flat K. The magnitude of corneal astigmatism was the measured difference between the steepest and flattest meridians, with its location (astigmatism meridian) along the steepest corneal meridian. Astigmatism analysis was performed only in eyes that had more than 0.50 D of anterior corneal astigmatism measured by the Placido topographer. The corneal astigmatism was expressed and compared using power vector analysis.[11] Briefly, each astigmatism value was converted to a Jackson (J) cross-cylinder notation represented by the rectangular vectors J0 and

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