Contact Lens & Anterior Eye 38 (2015) 363–367

Contents lists available at ScienceDirect

Contact Lens & Anterior Eye

journal homepage: www.elsevier.com/locate/clae

Comparison of keratometry and white-to-white measurements obtained by Lenstar with those obtained by autokeratometry and corneal topography

Jinhai Huang[a,b], Giacomo Savini[c], Binbin Su[a,b], Rui Zhu[a], Yifan Feng[a,b], Shishi Lin[a], Hao Chen[a,b], Qinmei Wang[a,b,*]

[a] School of Optometry and Ophthalmology and Eye Hospital, Wenzhou Medical University, Wenzhou, Zhejiang, China
[b] Key Laboratory of Vision Science, Ministry of Health P.R. China, Wenzhou, Zhejiang, China
[c] G.B. Bietti Foundation IRCCS, Rome, Italy

ARTICLE INFO

Article history:
Received 31 August 2014
Received in revised form 31 March 2015
Accepted 10 April 2015

Keywords:
Keratometry
White-to-white
Optical low coherence reflectometry
Topography

ABSTRACT

Purpose: To compare anterior eye segment measurements obtained using low optical coherence reflectometry (LENSTAR LS900, Haag-Streit), autokeratometry (RC-5000, Tomey) and corneal topography (Topolyzer, Wavelight).
Methods: In 46 healthy subjects, flat keratometry (K_f), steep keratometry (K_s), mean keratometry (K_m) and white-to-white (WTW) distance were measured by Lenstar, Tomey RC-5000 and Topolyzer.
Results: K_f and K_m measurements of Lenstar were significantly steeper than Tomey RC-5000 (both $p < 0.001$), but the 95% LoA of them were narrow (−0.22 to 0.46 D, −0.16 to 0.36 D, respectively). There were no significant differences between the K_f and K_m measurements of Lenstar and Topolyzer, with a narrow 95% LoA. There were no significant differences between the K_s measurements of Lenstar and Tomey RC-5000, and Lenstar and Topolyzer. A good agreement was found between them with 95% LoA of −0.40 to 0.56 D, and −0.56 to 0.64 D, respectively. WTW measurements with Lenstar were greater than those with Tomey RC-5000 and Topolyzer ($p = 0.042$, $p < 0.01$, respectively). A good agreement existed between the WTW obtained by Lenstar and Topolyzer, Tomey RC-5000, with 95% LoA ranging from −0.13 to 0.74 mm and −0.33 to 0.51 mm.
Conclusions: Generally good agreement was found between the Lenstar and Tomey RC-5000, Topolyzer for *K* and WTW measurements. In clinical practice, *K* and WTW measurements obtained by Lenstar and Tomey RC-5000, Topolyzer can be used interchangeably.

1. Introduction

Accurate ocular biometric measurements are particularly important for correct diagnosis and treatment of anterior eye disorders. Keratometry (*K*) is important for intraocular lenses (IOL) power calculation especially for Toric IOL power calculation, monitoring corneal disorders such as keratoconus, screening and assessing and the fit of customized contact lenses, and managing contact-lens-related and orthokeratology complications [1–4]. An exact measurement of white-to-white distance (WTW) is important for IOL power calculation using the fourth generation formulas, as well as in planning phakic IOL implantation [5–7]. In addition, precise WTW measurements are required to contact lens practice. The size of soft contact lens (SCL) is chose according to cornea diameter as the measurement of WTW distance. Commonly, total SCL diameter is larger than cornea diameter so that the lens can cover the whole cornea while in motion. A larger lens diameter will result in more discomfortable because of the effect of eyelid. For a smaller lens diameter, the lens center locating and the comfort will be poorer while blinking. So an accurate WTW measurement is important for SCL fitting.

At present, there are several commercially available instruments available for the measurement of *K* and WTW, including manual and automated keratometry, Scheimpflug imaging, Placido-disc corneal topography, slit-scanning tomography, and optical coherence tomography. The Lenstar LS900 (Haag-Streit AG, Koeniz, Switzerland), is a non-contact ocular biometer based on optical low-coherence reflectometry (OLCR) and measuring *K* by

* Corresponding author at: Eye Hospital of Wenzhou Medical University, 270 West Xueyuan Road, Wenzhou, Zhejiang 325027, China. Tel.: +86 577 88068880; fax: +86 577 88832083.
E-mail address: wqm6@mail.eye.ac.cn (Q. Wang).

http://dx.doi.org/10.1016/j.clae.2015.04.003
1367-0484/

means of dual zone automated keratometry. A single measurement can provide central corneal thickness, anterior chamber depth, *K*, WTW, axial length, lens thickness, retina thickness, pupil size, and visual axial decentration [8,9]. It has been the first competitor for the IOLMaster (Carl Zeiss, Jena, Germany) since the latter was introduced in 1999 and has been shown to provide accurate and reproducible measurements [8–11]. Hence it can now be considered a benchmark for comparison. A few studies have previously compared Lenstar to other instruments, such as the Pentacam (Oculus, Wetzlar, Germany) [12–15], manual keratometer [13,14], Javal (Rodenstock GmbH) [13] and KR-1W (Topcon Corp, Tokyo, Japan) [13]. However, no studies investigated agreement between the Lenstar and any Placido disc based corneal topographer, which is quite surprising since simulated keratometry has been demonstrated to be one of the most reliable options for IOL power calculation [16].

The aims of the present study were to compare the K_f, K_s, K_m and WTW measurements provided by the Lenstar with those provided by a Placido disc corneal topographer (Topolyzer, WaveLight Technologie AG, Erlangen, Germany) and an automated keratometer (RC-5000, Tomey, Inc., Nagoya, Japan).

2. Subjects and methods

Forty-six adult subjects (19 males and 27 female), with a mean age of 23.4 ± 5.4 years (range, 18–38 years), were recruited in this prospective study. The mean manifest spherical equivalent refraction (M) was −4.6 ± 2.8 diopters (range, −11.4 to 1.3 diopters), Jo was 0.32 ± 0.38 diopters (range, −0.48 to 1.58 diopters), and J45 was 0.02 ± 0.27 diopters (range, −0.56 to 1.23 diopters) [17]. The exclusion criteria were age younger than 18, previous ocular surgery, corneal pathologies such as keratoconus and ectasia, cataract, glaucoma, fundus disease, contact lens wear (rigid contact lens within 4 weeks and soft contact lens within 2 weeks), dry eye and intellectual disability. All procedures adhered to the principles of the Declaration of Helsinki, and the protocol was reviewed and approved by the Research Review Board at Wenzhou Medical University. Before measurement, we explained the purpose, risks, discomfort, and steps of the study to each subject. Written informed consent was provided by each subject. All subjects had good corrected distance visual acuity equal to or better than 20/25 to allow for adequate fixation.

The K_f, K_s, K_m and WTW Measurements obtained using Lenstar were compared with those provided by Tomey RC-5000 automated keratometer and Topolyzer corneal topographer. For each instrument, three measurements were taken on each subject, and the results were averaged. The order of measurements taken using the three instruments was randomized for all subjects. Only the right eye of each subject was scanned. All measurements were performed by the same well-experienced investigator within the same session. All subjects were asked to blink just before measurements were taken.

Lenstar can measure corneal power by analyzing the reflected image of two rings of light-emitting diode (LED) light sources (16 each) on 1.65 mm and 2.30 mm diameters of the anterior surface of the cornea, of wavelength 950 nm. This so-called “dual-zone” keratometry is different from “single-zone” keratometry such as Tomey RC-5000 and IOLMaster auto-keratometry. The flattest *K* and steepest *K* measurements are averaged and recorded as K_m. Lenstar automatically measures the WTW by fitting the best circle on the edge of the iris with the aid of installed proprietary software (version 2.12). For each measurement, the subject was asked to fixate on a flashing red light to ensure that all measurements were taken on the visual axis.

The Tomey RC-5000 autorefractor keratometer (version 1.26) is designed based on the optical principle represented by the relationship between the size of an object and the size of the image of that object reflected from a surface. Assuming the cornea is a convex mirror, the automated keratometer instantly records the size and computes the radius of curvature, while focusing the reflected corneal image (infrared illuminated mires) onto an electronic photosensitive device (infrared detectors). The device acquires radius of curvature measurements in the flat and steep meridians on a 3.0 mm and a 6.0 mm diameter field of the central cornea. The 3.0 mm diameter readings were chosen. Keratometric measurements are obtained by converting the measured radius into diopters, using the Standard Keratometric Index (SKI) of 1.3375, which corresponds to that used for Lenstar.

The Allegro Topolyzer (version 1.59) is based on Placido disk-based videokeratoscopy. It contains 22 rings and measures and generates high-resolution data of the corneal surface with 22,000 points. The device presents the keratometric data across three separate corneal zones: a central zone with a 3.0 mm diameter, a paracentral zone with a 5.0 mm diameter, and a peripheral zone with a 7.0 mm diameter. In this study, the 3.0 mm zone readings were chosen for improved correlation with the central optical zone and with the areas of measurement covered by the other devices.

For obtaining measurements using Tomey and Topolyzer, the subjects were asked to fixate on the target in their system, and measurements were performed according to the manufacturer’s recommendations. The measurements of the flattest corneal curvature and the steepest corneal curvature were averaged in order to be compared with the K_m of Lenstar. The WTW measurements were also recorded.

2.1. Statistical analysis

Statistical analysis was performed using the SPSS software for Windows version 13.0 (SPSS, Inc., Chicago, IL, USA) and Microsoft Office Excel. The distributions of the datasets were checked for normality using the Kolmogorov–Smirnov tests. The results indicated that the data were normally distributed. The results were presented as mean ± standard deviation (SD). For multiple comparisons between Lenstar and other devices, the repeated-measures analysis of variance (ANOVA) with Bonferroni correction was applied to the post-hoc testing. The agreements between Lenstar vs. Tomey, and Lenstar vs. Topolyzer were evaluated by Bland and Altman analysis (95% limits of agreement (LoA) were plotted as the mean difference ± 1.96 SD) [18,19]. A *p*-value of less than 0.05 or equal to was considered statistically significant.

3. Results

Table 1 shows the mean values of K_f, K_s, K_m, and WTW, as measured by Lenstar, Tomey RC-5000 and Topolyzer. Table 2 shows the mean difference and 95% confidence interval (CI) between the measurements obtained by Lenstar and Tomey RC-5000 and Lenstar and Topolyzer.

The K_f and K_m measurements provided by Lenstar were higher than Tomey RC-5000 (both $p < 0.001$), while K_f and K_m measurements obtained by Lenstar and Topolyzer were not significantly different ($p = 0.092$ and $p = 0.281$, respectively). The K_s values obtained by Lenstar and Tomey RC-5000, and also Lenstar and Topolyzer were not significantly different ($p = 0.098$ and $p = 1.000$). The mean WTW values provided by Lenstar were significantly greater than those provided by RC-5000 and Topolyzer ($p = 0.042$ and $p < 0.001$).

Figures 1–4 show the Bland–Altman plots for the K_f, K_s, K_m, and WTW measurements. With regard to K_f, K_s and K_m, good