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Comparative study for evaluation of the horizontal white-to-white corneal diameter using the optic low-coherent reflectometer and the scheimpflug topography in normal Egyptian population

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***Abstract*---**Purpose: Comparison of the horizontal white-to-white corneal diameter measured by Lenstar LS 900® (Haag-Streit AG, Koeniz, Switzerland) and TOMEY TMS-5® (topographic modeling system, version 5) to assess the agreement between them. Setting: El-Agouza police hospital, Egypt. Materials and methods: Comparative prospective cross-sectional clinical study in which measurements of the horizontal WTW corneal diameter were obtained by LENSTAR LS900 and TOMEY TMS-5. Results: The study included 219 eyes of 115 randomly chosen normal Egyptian subjects of both sex (68 males and 47 females). The WTW diameters measured by LENSTAR LS900 and TOMEY TMS-5 ranged from 10.88 to 13.15 mm and 10.69 to 12.94 mm respectively. Lenstar LS 900 gives slightly higher values for WTW diameter than TOMEY TMS-5. Pearson coefficient of correlation (r) revealed a strong statistically significant level of correlation between WTW values measured by both devices ($r = 0.87$ with $p<0.01$). Paired samples t-test showed a small mean inter-device difference with high statistical significance (0.29 mm and $p<0.01$). The Bland-Altman limits of agreement for WTW values measured by them showed a LoA extending from -0.1 to 0.68 mm. Conclusion: The current comparative study between Lenstar LS 900 and TOMEY TMS-

5 found a high correlation with relatively good agreement between the two devices in measuring WTW corneal diameter in healthy eyes. However, the two devices cannot be used interchangeably. Caution must be used regarding WTW values produced by the two devices interchangeably because it may lead to misinterpretations of results. Consequently, it is important to utilize the same device during follow up of the patient. The difference between LENSTAR LS900 and TOMEY TMS-5 should be considered in the IOL formulas including WTW diameter and phakic IOLs calculation. This study points that the normal WTW diameter is broader than the existing accepted range. Further studies are needed to revise the cutoff points in the definition of microcornea and macrocornea referenced in textbooks based on different instruments utilized in measurement and the population's difference.

***Keywords*---**WTW, biometry, Lenstar, TOMEY.

Introduction

Precise measurement of the horizontal WTW corneal diameter is crucial and has several clinical applications. It is the horizontal distance between the two limbal areas of the cornea.[2] Lenstar LS 900 utilizes an optical low-coherent reflectometer with superposition of light waves to measure intraocular distances in a procedure close to the optical coherence tomography technique. It acquires 16 successive scans in a single measure without the demand for realignment. It gives reliable, reproducible and repeatable biometric values.[3]

The TOMEY TMS-5 combines a rotating Scheimpflug camera and a wide-angle Placido ring topography. The two acquisition steps are distinct, initially, it captures the ring topography (31 rings) then the 32 slit scan images and the data are fused at the end of the examination.[6] It provides reliable and user-independent biometric values.[1]

Methods

This study included 219 eyes of 115 randomly chosen normal Egyptian subjects of both sex (68 males and 47 females) meeting the inclusion criteria, eleven eyes were discarded due to the exclusion criteria. All subjects were recruited from the outpatient clinics of the ophthalmology department, El-Agouza police hospital with spherical equivalent from -2D to +2D. The parameters were obtained by using an optical low coherent reflectometer (LENSTAR LS-900) followed by Scheimpflug topography (TOMEY TMS-5) on the same day consecutively. Regarding both devices, subjects were comfortably positioned with a headrest and a chinrest then instructed to fixate on an internal target. The lateral canthi should be aligned with the side markers on the headrest's holding bars. Subjects were instructed to blink just before examinations for corneal covering with a clear tear film and then to keep both eyes opened. LENSTAR LS900 acquires 16 successive scans in a single measure without the demand for realignment and five

readings are obtained from each eye as the manufacturer recommended. The average of these five readings is calculated by the internal software and then utilized in subsequent assessments. TOMEY TMS-5 requires two acquisitions for each eye. Initially, it takes four measurements using a wide angle Placido ring topography (Ring Topo Mode) then the operator fully retracts the joystick and triggers the Scheimpflug camera (slit mode) and the data are fused at the end of the examination. All examinations were taken by a single skilled operator using criteria provided by the manufacturers of the devices in a dimly lit room without pupil dilation during the same time of the day from 10 AM to 2 PM within the shortest time possible and at least three hours after wakeup time to avoid the effect of diurnal variation in corneal thickness. This study was performed according to the ethical standards listed by the Ethical Committee of Beni-Suef University. Informed consent was acquired from each patient following the clarification of the academic character of the study.

Statistical analysis

The measurements derived from both devices were gathered, revised and submitted to IBM SPSS version 22 (IBM Inc., Chicago, Illinois, USA). Kolmogorov-Smirnov test was applied to confirm the normality of all anatomic data distributions. Description of quantitative variables: number (n), range (minimum and maximum), mean and SD. Paired samples t-test was applied to compare parallel quantitative parameters from the two devices. An independent t-test was carried out to detect significant differences. Pearson coefficient of correlation (r) was used to test how variables correlate together. The confidence interval was adjusted to 95% and the accepted error limits were adjusted to 5%. Therefore, the p-value (probability) is considered significant when $p \leq 0.05$. The Bland-Altman method was applied to assess the agreement between the two instruments. The limits of agreement (LoA) were determined as the mean difference between the two devices ± 1.96 times the SD of the differences. The magnitude of these limits verifies whether the two devices can be considered in agreement and whether they can be interchangeably used. If the 95% LoA are within allowable clinical limits, the two instruments can be interchangeably used.

Results

The study sample included 219 eyes of 115 patients, There were 91 eyes of female patients (41%) and 128 eyes of male patients (59%). The mean age was 37.5 years within a range of 25 years (minimum 25 years and maximum 50 years). The mean spherical equivalent ranged from -1.75 to +1.25. The mean and standard deviation of WTW diameter measured by the Lenstar LS 900 and TOMEY TMS-5 was 12.10 ± 0.40 and 11.81 ± 0.40 respectively. Paired samples t-test showed small mean inter-device differences with high statistical significance in the mean WTW values (**Table 1)**. Pearson coefficient of correlation (r) revealed a strong statistically significant level of correlation between the mean WTW values measured by the two devices (**Table 1).** The Bland-Altman limits of agreement for WTW values measured by the two devices showed a LoA extending from -0.1 to 0.68 mm (**Figure 1 and Table 1)**.

Table (1)
The mean inter-device difference, Pearson correlation coefficient (r) and LoA for WTW values measured by LENSTAR LS 900 and TOMEY TMS-5

WTW	mean difference	SD	95% limits of agreement (LoA)		P-value	r	P-value
			Lower	Upper			
Lenstar &Tomey	0.29	0.20	-0.1	0.68	0.000	0.87**	0.000

** *Significance is at the 0.01 level.*

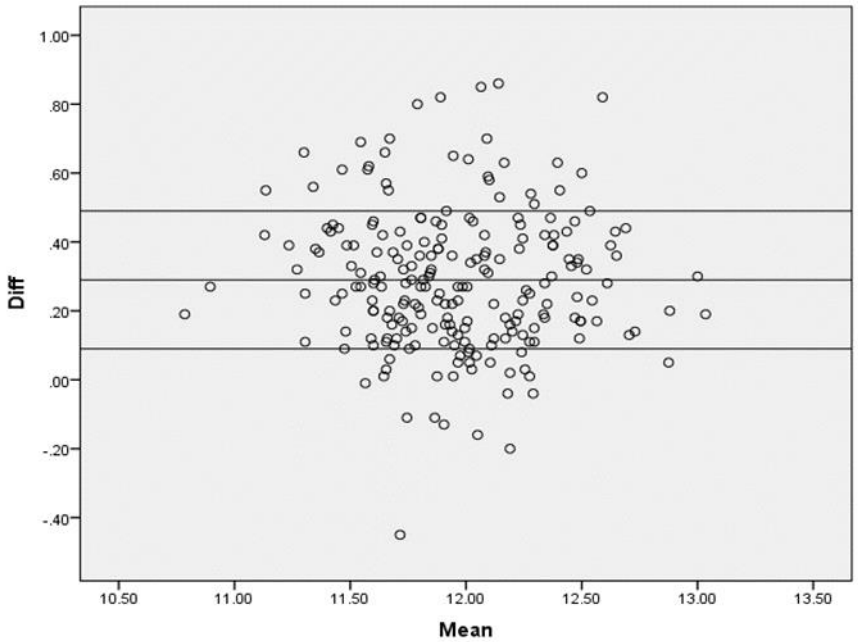

Figure (1): Bland-Altman plot

(Diff is the difference between WTW values measured by LENSTAR LS 900 and TOMEY TMS-5, Mean is the mean of the two same variables and lines are the Mean ±SD).

Discussion

Nowadays several devices are available to measure the ocular anterior segment parameters. These devices depend on different optical principles for measuring these parameters. Evaluation of the precision and the accuracy of these devices is crucial before their usage in clinical applications and research. This study aimed to assess and compare the horizontal WTW corneal diameter measured by Lenstar LS 900 and TOMEY TMS-5 to assess the agreement between them. Both devices use different technology and provide reliable anterior segment

measurements. In the current study, some studies are comparing LENSTAR LS 900 or TOMEY TMS-5 to other devices with closely related technology while some studies compare one of them to other devices with different technology.
Regarding the horizontal corneal WTW diameter, the exact range of the normal WTW diameter is unclear. The present agreed range for normal WTW diameter (> 11.00 to < 13.00 mm in adults) has not been confirmed by evidence-based studies. The normal range of WTW diameter is slightly different among studies partially depending on the method used for its measurement. Furthermore, the existing definitions of microcornea and macrocornea stated in several textbooks vary from source to source.

In the present study, the WTW diameters measured by LENSTAR LS900 and TOMEY TMS-5 ranged from 10.88 to 13.15 mm and 10.69 to 12.94 mm respectively. Based on these results, the normal WTW is wider than the currently accepted range (> 11.00 to < 13.00 mm) by expanding both its upper and lower limits which agrees with the study by **Chen and Osher**.[2] The later claimed a definition for macrocornea; a corneal WTW diameter more than 13.2 mm. Whereas, **Gao et al.**[5] documented the lower limit of WTW measurements by LENSTAR LS900 to be 10.86 mm in accordance with the present study.

This indicates that the real upper limit of normal WTW diameter may be shifted towards the right while the real lower limit may be shifted to the left. Thus, the normal WTW diameter is broader than the existing accepted range.

This study directs the demand for further studies to revise the cutoff points in the definition of microcornea and macrocornea referenced in textbooks based on different instruments utilized in measurement and the population's difference.

In the present study, the mean corneal WTW diameters measured by LENSTAR LS900 and TOMEY TMS-5 were 12.10 ± 0.40 mm and 11.81± 0.40 mm respectively. Accordingly, LENSTAR LS900 provided higher WTW values than TOMEY TMS-5 in agreement with the study by **Sen et al**.[7] The later study reported that LENSTAR LS900 slightly overestimate WTW than Pentacam HR. The mean WTW values measured by LENSTAR LS900 and Pentacam HR (Oculus) were 11.95 ± 0.39 mm and 11.67 ± 0.34 mm respectively. **Sen et al.**[7] suggested an explanation for this observation; LENSTAR LS900 estimates the corneal WTW diameter as the horizontal iris width (manufacturer guidelines) while the Scheimpflug camera in TOMEY TMS-5 acquires 25 images for each measurement from different directions then the mean of them is calculated. As known, the cornea in adults is nearly 12 mm in horizontal diameter and 11 mm in vertical diameter.

In the current study, the mean inter-device difference between LENSTAR LS900 and TOMEY TMS-5 was 0.29 mm with a high statistical significance ($p < 0.01$). This difference is close to the mean inter-device difference found between LENSTAR LS900 and Pentacam HR (Oculus) for WTW measurements (0.27mm) as reported by **Sen et al**.[7] The later study found a significant difference between the two instruments thus they can't be used interchangeably. In the current study, there was a moderate correlation with high statistical significance ($r=0.87$ and

p<0.01) between WTW values measured by TOMEY TMS-5 and LENSTAR LS900. The Bland-Altman limit of agreement for WTW values measured by LENSTAR LS900 and TOMEY TMS-5 was wide; ranging from -0.10 to 0.68 mm (>0.5mm) which is not suitable for the selection of the proper diameter of phakic IOL and should be considered clinically significant. Furthermore, considering FDA (Food and Drug Administration) tolerance limits and that IOLs are sized to the nearest 0.50 mm as reported by **Domínguez-Vicent et al.**[4], these two instruments cannot be used interchangeably. In accordance with the previous results, **Sen et al.**[7] found that LENSTAR LS900 and Pentacam HR (Oculus) have a wide 95% LoA (-0.09 to 0.64 mm) thus they can't be used interchangeably in clinical practice.

In conclusion, although the WTW measurements of LENSTAR LS900 versus TOMEY TMS-5 do not show a great mean inter-device difference with moderate correlation between them, their 95% LoA is broad and clinically significant which is not acceptable for the two devices to be used interchangeably under certain clinical circumstances. This significance depends on the clinical situation considered that should be determined for each application by the clinician. Thus, caution must be used regarding WTW measurements produced by the two devices interchangeably. This difference between them should be considered in the IOL formulas including WTW diameter and phakic IOLs calculation.

In earlier studies, the agreement in WTW measurement was not good all the time due to the technology of edge recognition. The use of different methodologies, differences in digital image processing and in defining the limbus by each instrument, could be a partial explanation. LENSTAR LS900 measures WTW diameter by an imaging procedure utilizing the corneoscleral contrast zones as a reference mark. The WTW distance is achieved by fitting the best circle with the lowest error square to the detected edge. It is determined by analysis of the iris image and the corneal radius of curvature acquired from keratometry. LENSTAR LS900 utilizes a light emitting diode (950nm) for measurements of the WTW diameter. While; the Scheimpflug camera in TOMEY TMS-5 utilizes blue light emitting diode (475 nm). It acquires 25 images for each measurement from different directions then the mean of them is calculated.

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Declaration of conflicting interests

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