Precision of pachymetric measurements with Scheimpflug –Placido disc cornealTopography and comparison of these measurements with ultrasonic pachymetry

Suzan Amana Rattan, MBChB, FICMS (Oph.)

ABSTRACT

Back ground: Several devices with different physical bases have been developed for the clinical measurement of corneal thickness, they classified into 4 categories: Scheimpflug photography based, Slit –Scanning topography, optical coherence tomography (OCT) based and ultrasound (US) based.

Objective: To evaluatethe precision of the new Scheimpflug –Placido disc corneal topography in measurement of corneal thickness and to compare the measured values with that obtained by US pachymetry.

Methods: Setting of this study is Lasik center in Eye Specialty Private Hospital. Baghdad. Iraq.Eyes of healthy subjects were examined with the Sirius topography.3 consecutive measurements of central (CCT)and thinnest (TCT) corneal thicknesses were obtainedand the measurements repeated within 1 week. The within –subject standard deviation (Sw),test-retest repeatability ,coefficient of variation (CoV),and interclass correlation coefficient (ICC) were calculated to evaluate intra session repeatability and intersession reproducibility. For US pachymetry (Tomey-SP 100) only CCT was measured. Comparison ofthe measurements that obtained by the 2 devices done by paired *t*-test.

Results: The topography provides high intrasession repeatability with test-retest and CoV close to 6µm and 0.4%, respectively for both CCT and TCT. The inter session reproducibility also high with test-retest and CoV close to 8µm and 0.5%, respectively.ICC was higher than 0.97 for repeatability and reproducibility . Anarrow 95% limit of agreement was found between the pachymetry obtained by topography and US pachymetry measurements.

Conclusions :The topography has been used showed high intrasession repeatability and intersession reproducibility of CCT and TCT measurements in healthy eyes .Absence of statistically significant differences suggest that the topography -TCT and the US pachymetry - CCT can be used interchangeably in subject with normal cornea**.**

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Keywords: Scheimpflug -Placidotopography, US: Ultrasonicpachymetry. Abbreviations: CCT: central corneal thickness, TCT: thinnest corneal thickness.

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** Al-Kindy Medical College, University of Baghdad.*
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Corresponding to Suzan Amana Rattan; email: moonlightmoon89@gmail.com, mobile; 07709852777

The precision of corneal thickness measurement is crucial part of advanced ophthalmologic examination .Accurate measurement of central corneal thickness (CCT)allows the surgeon to safely plan corneal refractive procedures ,thus reducing the risk for postoperative complication such asectasia .In cases in which surgery has been performed and an enhancement required ,underestimating the CCT may exclude some patients who are eligible ,whereas overestimating the CCT may increase the risk for corneal ectasia[1,2]

Accurate CCT measurement can be used to correct intraocular pressure values,as measured by Goldmann applanation tonometry[3] and are important when monitoring corneal disorders,such as keratoconus,contact lens-related complications,and dry eye[4,5].

Several devices with different physical bases have been developed for the clinical measurement of corneal thickness,they classified into four categories: Scheimpflug photographybased,Slit –Scanningtopography, optical coherence tomography (OCT) based and ultrasound(US) based[6].

Hand held (ultrasound) US pachymetry is often used as reference for CCT determination.It characterized byits cost effectiveness,ease of use,and high repeatability[7].However, thistechnique has disadvantages,such as the need for topical anesthesia, direct contact with cornea ,which may result in a risk of corneal epithelial damage and infection. Other studies found that the precision of US pachymetry was operator dependent so the placement of the probe exactly on the center of the cornea is crude and consequently off center placement mayyield thicker measurement than the true central corneal thickness[8].

The optical pachymetric systems have been used to overcome these limitations of US pachymetry provide rapid ,convenient, noncontact and objective measurement of CCT.

A numerous studies show the relevance and usefulness of noninvasive optical technologies in clinical practice, which allow consistent corneal pachymetric mapping in very few seconds. Specifically,pachymetry by OCT and Scheimpflug photography has been shown to be reliable and noninvasive.[9]

In this study we aim to evaluate the intrasession repeatability and intersession reproducibility of central corneal thickness CCT and the thinnest corneal thickness TCT measurements derived by the Scheimpflug- Placido corneal topographer and compare these measurement with those we obtained by using USpachymetry.

Methods:This prospective study included 120 eyes of 120 persons attended for refractive surgery to theLasikcenter at

Eye Specialty Private Hospital in Baghdad, Iraq.The right eye for each patient was taken for measurements that included in the study. Each subject gave informed consent after the nature and intent of the study had been fully explained.

Inclusion criteria: Myopic sphere of -0.50 to -6.00 diopter(D) with or without astigmatism up to- 2.00D,age range of the patients 20-35 years no previous ocular surgery and no any ocular pathology.

Scheimpflug camera -Placido disc topography:The Sirius system combine amonochromatic 360 rotating Scheimpflug camera and aPlacido disc- based corneal topography .The scanning process acquires a series of 25 Scheimpflug images (meridians) and 1Placido top-view image .

The ring edges are detected on the Placido image so that the height, slop, and curvature data are calculated using the arc -step method with conic curves. Profiles of the anterior cornea, posterior cornea ,anterior lens and iris are derived from the Scheimpflug images. Data for the anterior surface from Placido images and Scheimpflug images are merged using a proprietary method .All other measurement of internal structures(posterior cornea,anterior lens and iris)are derived solely from Scheimpflug data.

The system can measure 35632 points and 30000points for the anterior corneal surface and posterior corneal surface,respectively. A pachymetrymapis then reconstructed using the data from both corneal surfaces .In this study the CCT and TCTwere recorded and analyzed.

Measurement Protocol:

In the first part of the study ,the precision of rotating Scheimpflug -Placido topographer was determined based on the definitions adopted by the international organization of standardization [10,11]as recommended by Bland and Altman[12] .Each subject was measured by the same experienced examiner ,and the first session was designed to determine intra observer repeatability .Three valid scans were performed ,after each acquisition ,the device was moved backward and realigned for the next scan to eliminate interdependence of the successive measurement s. The total time for acquiring all measurement s did not exceed 10 minutes. Intra session reproducibility was assessed by additional 3 scans performed 2 to 7 days later and by the same examiner. In the second part of the study, the accuracy of corneal thickness measurement by the Scheimpflug -Placido topographer and by US pachymetry was compared. In the 1stsession after the noncontact examination was performed, the cornea was anesthetized with propracaine hydrochloride 0.5% (alcaine). The A scan US pachymeterwas precalibrated for all measurement. The US velocitywas set at 1640 m/s .Ahand held probe wasalignedas perpendicularly as possible to the central cornea.Five readings were obtained, the mean was taken as US pachymetry -CCT.This value was then compared with the mean CCT and the TCT value provided by Scheimpflug -Placido topographer.All these measurement were taken between 10 AM and 2PM to minimize the effect of diurnal variation on corneal thickness[13].

Statistical analysis:

All data were analyzed using the SPSS for Windows software (version 13.0, SPSS, Inc.) and Minitab (version13). Results are presented as mean ±standard deviation (SD).The distributions of the datasets were checked for normality using Kolmogorov-Smirnov tests. The results indicated that the data were normally distributed ($p<0.05$).

To determine the intrasession repeatability of each device, the within-subjects(Sw),test -retest repeatability(test-retest,2.77Sw),within -subject coefficient of variation (CoV),and intraclass correlation coefficient(ICCs) were calculated for the 3 repeated measurements[14]. The test -retest was defined as 2.77Sw, which means an interval within which 95% of differences of measurements are expected to lie[14] .the CoV was calculated as the ratio of the Sw to the overall mean .A lower CoV is associated with higher repeatability .The ICC(range 0 to 1) determines the consistency for the datasets of repeated measurements. The closer the ICC to 1,the better the measurement consistency .The intersession reproducibility of the measurement method was evaluated by ICC .Measurements from the 2 sessions were compared using a paired-*t* test.

Comparison of mean of CCT and TCT by Scheimpflug -Placido topographer and US pachymetry -CCT was performed using paired t test. The 95% limit of agreement (LoA) was defined as the means ±1.96 SD of differences between the 2 measurements techniques[12].

Results:

The study comprised 120 eyes from 120 persons (80 women and 40 men) with mean age 26.5ys ±7.8 (SD). The mean manifest spherical equivalent refraction was -3.85D±1.98.

Repeatability and reproducibility of central cornealthickness and thinnest corneal thickness measurements:

Measurement of CCT and TCT with Scheimpflug -Placido topographer showed high intrasession repeatability (table 1). The intrasession test -retest (2.77Sw) andCoV were close to 6µm and 0.4%, respectively, the ICC was higher than 0.98.

There were no statistical significant differences in the measurements between 1st and 2nd session which confirms intra session reproducibility .The test-retest (2.77Sw)and CoV were close to 8µm and 0.5% , respectively, and the ICC was also higher than 0.97 (table 2).

Agreement between the topography and ultrasound pachymetry measurements:

The mean US pachymetry CCT was 530.93 µm±25.19.The mean topographic -CCT and TCT were537.24 µm±25.20and 531.48µm±25.09 respectively .The mean CCT by Scheimpflug -Placido topographer was significantly higher than the mean USpachymetry -CCT by 6.31 µm and P Value=0.000.There were no statistically significant differences between the latter and the topographic- TCT measurement P Value=0.56(Table 3).In terms of the agreement between different devices, the CCT and TCT measurement showed narrow 95% LoA ,which implied good agreement between pachymetry obtained by US and topography.

There is strong linear correlation between the topographic TCT and US-CCT ,r=0.99 and P value for Pearson correlation is 0.000.

Table 1.intra observer repeatability of CCT and TCT readings by the topography

parameter	Mean(µm)±SD	Sw(µm)	2.77Sw(µm)	CoV (%)	ICC	95% CI
CCT	537.24±25.20	2.47	6.84	0.46	0.99	0.98,0.99
TCT	531.48±25.09	2.43	6.73	0.45	0.99	0.98,0.99

CCT=central corneal thickness; CI: confidence interval ;ICC=interclass correlation coefficient; Sw= within -subject standard deviation ;TCT= thinnest corneal thickness ;CoV=coefficient of variation

Table 2.intersession reproducibility of CCT and TCT readings by corneal topography

parameter	Mean difference ±SD	Sw(µm)	PValue	2.77Sw(µm)	CoV (%)	ICC	95% CI
CCT	˗0.40 µm ±1.0	2.92	0.90	8.09	0.55	0.98	0.97,0.99
TCT	˗0.10µm±0.7	2.75	0.97	7.62	0.52	0.98	0.97,0.99

CCT=central corneal thickness; CI: confidence interval ;ICC=interclass correlation coefficient; Sw= within -subject standard deviation ; TCT= thinnestcorneal thickness ;CoV=coefficient of variation

Table3:Comparison of CCT ,TCT readings by Topography and CCT by ultrasound pachymetry

parameter	Mean Difference(µm)±SD	P Value	95%LoA (µm)
CCT	6.31±2.09	0.000	2.21 -10.40
TCT	0.55±1.05	0.56	-1.50-2.61

CCT=central corneal thickness; LoA=limits of agreement ;TCT= thinnest corneal thickness

Discussion:

This study was prospectively designed (1) to evaluate the precision of CCT and TCT measurement by Scheimpflug - Placido topographer and (2) to evaluate the agreement between these measurements with ultrasonic pachymetry measurements. Our results confirm the high repeatability of the topographic measurements of the thinnestpachymetry TCT andcentral corneal thickness CCTin normal eyes.The ICC was close to 1,the intrasession CoV was lower than (0.5%) and the test-retest was close to 6µm for CCT and TCT. Furthermore, we found that pachymetric measurements of the topography confirm the high degree of reproducibility since there is no statistical significant difference between 1st and 2nd session measurement for both CCT and TCT were P Value >0.05.

Asimilar result with the same device was reportedby Jinhai Huang [15],the ICC was 0.991 and the intrasession CoV was lower than 0.65% for both CCT and TCT whiletest -retest was 9.06µmfor CCT and 8.96µmfor TCT.Montalbanet al[16].also report a CoV and ICC values of 0.52% and 0.997, respectively for both CCT and TCT.

Several authors assessed the repeatability of CCTmeasurement with other Scheimpflug or Scheimpflug - Placido system, all devices show high degree of repeatability[17–19] but one them provides the highest repeatability[20,21] this may be due to the 2 opposite Scheimpflug cameras and the data acquired by the 2 cameras are averaged to compensate for possible misalignment in pachymetric measurements due to eye movements[22].However, because this is an indirect comparison of Scheimpflug based- systems, we cannot make direct conclusions as to which device shows the best repeatability of CCT measurements.Therefore, a future study is needed to compare the four Scheimpflug devices under the same conditions and at the same time.

In our study we found that the mean CCT Scheimpflug - Placido topographer overestimated the mean US pachymetry -CCT by average of (6.31µm) .On the contrary

,no statistically significant difference was found betweenthe topography-TCT and US pachymetry CCT.These differences are clinically insignificant and are consistent with those in previous studies that compared other Scheimpflug cameras with US pachymetry in normal healthy cornea [23–26].

Several reasons may explain the discrepancy between the corneal topography andUS pachymetric values:

1st the corneal topography used the corneal vertex as reference center,while US pachymetry is centered on the pupil, 2nd the US pachymetry probe may displace the tear film and compress the epithelium leading to lower measured values[27,28], 3rd the accuracy of US pachymetry depend on the experience of the operator who must keep the probe perpendicular to the center of the corneal surface .This condition may not always achieved off center or oblique probe positioning ,ultimately yielding thicker CCT measurement ,4th the exact location of the posterior corneal reflection of US is unknown because it ranges from Descement membrane to the anterior chamber :if the posterior reflection is selected anterior to the endothelium ,the measurement s may be lower than the actual thickness[23]and finally the use of topical anesthetic drops may induce corneal edema ,thus increasing corneal thickness and influence the speed of US [29,30].

Agreement between the topographic system and US pachymetry –CCT was good for CCT and TCT as shown by the 95%LOA (from 2.21 to 10.40 µm and from -1.50 to 2.61 µm for CCT and TCT,respectively).The differences were small and comparable to thosein previous studies of95% LOA between the Scheimpflug or Scheimpflug Placido system and US pachymetry.[17,19] and our study shows the narrowest agreement limitfor both topographic-CCT and TCT with the CCT measured by US pachymetry (table3).

In conclusion, the Scheimpflug –Placido topographer showed excellent intra session repeatability and intersession reproducibility of CCT and TCT measurement in healthy eyes and good agreement with US pachymetry .The topographic- TCT and US pachymetry –CCT measurements can be considered clinically interchangeable in eyes with no corneal pathology and no previous corneal surgery.

Recommendations:This study has limitations that warrant further investigation:First, onlyone US pachymetrydevice was evaluated and our results may not be valid when considering other US pachymetry models .Second,it is not possibleto apply our findings to other conditions, such as keratoconus and eyes with any degree of corneal opacity thatcould induce mistakes in precision of an optical pachymeter. Third, the studydid not evaluate eyeswith hyperopia so our results cannot applied to this group of eyes .A future research may include these conditions.

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