Original Article

# Corneal Parameters Measurement in Healthy Subjects Using Scheimpflug and Anterior Segment Optical Coherence Tomography

**PJO – OfficialJournal of Ophthalmological Society ofPakistan**
Volume2023;39(4):273-278.
**Doi: 10.36351/pjo.v39i4.1666**



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## Abstract

**Purpose:** To compare the central corneal thickness (CCT), minimum corneal thickness (MCT) and corneal power measured using the Scheimpflug-Placido device and optical coherence tomography (OCT) in healthy eyes.

**Study Design:** Descriptive observational.

**Place and Duration of Study:** Al-Kindy college of medicine/university of Baghdad, from June 2021 to April 2022.

**Methods:** A total of 200 eyes of 200 individuals were enrolled in this study. CCT and MCT measurements were carried out using spectral-domain optical coherence tomography (Optovue) and a Scheimpflug-Placido topographer (Sirius). The agreement between the two approaches was assessed using Bland-Altman analysis in this study.

**Results:** Mean age was 28.54 ± 6.6 years, mean spherical equivalent of refraction was -3.57 ± 3.35 D. Mean CCT by Optovue, and Sirius were 534.13 ± 27.88 µm, and 540.2 ± 27.85 µm, respectively. Mean CCT differences between them were -6.070 ± 6.593 µm, ($p < 0.05$). Minimum thickness by Optovue was 526.79 ± 27.81, and by Sirius was 537.44 ± 27.56, mean difference between the two devices was 10.66 ± 6.89, $p = 0.00$. The net power by OCT was 43.44 ± 1.456, mean K by Sirius was 43.597 ± 1.408, with $p = 0.000$. Maximum level of agreement between the two devices is -18.99 to 6.85 for CCT, is widest for minimum thickness -24.166 to 2.85 and narrowest for differences between net corneal power by OCT and mean K By Sirius is -0.87 to 1.18.

**Conclusion:** In clinical practice, the two devices cannot be used interchangeably. CCT and keratometry should be evaluated and followed up using the same device.

**KeyWords:** Corneal thickness, central corneal thickness, Optovue, Pachymetry, Sirius.

**How to Cite this Article:** Rattan SA. Corneal Parameters Measurement in Healthy Subjects Using Scheimpflug and Anterior Segment Optical Coherence Tomography.

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*Received: June 03, 2023*
*Accepted: September 04, 2023*

## INTRODUCTION

For clinical measurement of corneal thickness, several devices are commercially available where all have different physical bases. They are classified into four main categories including "ultrasound (US)-based, Scheimpflug-based, slit scanning topography-based, and optical coherence tomography (OCT)-based".[1]

US pachymetry is regarded a reference for corneal thickness measurement. It is characterized by its simplicity of usage, cost-effectiveness and its repeatability. The disadvantages include requirement of topical anesthesia due its direct corneal contact. The contact nature of this device may lead to corneal epithelial damage and possible corneal infection. The measurement by US pachymetry is operator dependent. Therefore the central probe positioning during measurement determines accurate reading.[2,3]

Newer devices use non-contact techniques whichare usually operator independent and have rapidmeasurement time.

Several articles are available in literature comparing different devices for precision and repeatability of corneal parameters.[2] The goal of current study is to compare central corneal thickness, minimum corneal thickness and corneal power between OCT and Scheimpflug-Placido corneal topography.

## METHODS

A cross-sectional study wasconducted, that comprised (200 eyes of 200 subjects) who visited refractive center in Eye specialty private hospital from 1st of JUNE 2021 to 1st of April 2022 for pre-operative assessment for refractive surgery. Right eye was chosen for analysis. Ethical committee of Al-Kindycollege of medicine approved the study. The enrolled subjects provided informed written permission.

Their age ranged from 20 to 35 years. One hundred ten subjects were females and 90 were males. Their Log MAR uncorrected visual acuity (UCVA) was 0.323 ± 1.488. Their LogMAR best-corrected visual acuity (BCVA) was 0.94 ± 0.96 and spherical equivalent refraction (SE) was -3.536 ± 3.327 D.

Subjects with normal topography and clear cornea on slit lamp examination were included in the study. Individuals with previous eye surgery, trauma, infection or corneal degeneration or dystrophy was excluded. Subjects with previous eye surgery with contact lens wear within the last two weeks were also excluded from the study.

All the subjects had corneal parameters measurement done with the Sirius topography and then with anterior segment OCT later on the same day. The two measurements were taken by single trained operator.

The Sirius system combines a Placido-disc-based corneal topography with a monochromatic 360° spinning Scheimpflug camera. For each scanning process, a set of twenty-five Scheimpflugimages and one Placido top-view image were taken.

The ring borders on the Placido image are identified and the slop, height and curvature data can be calculated using the arc step procedure with conic curves. The Scheimpflug-images were used to create profiles of posterior cornea, anterior cornea, anterior lens and iris. A proprietary method was used to integrate data for the anterior surface from Placido images and Scheimpflug images. All additional measurements of internal structural "posterior cornea, anterior lens and iris" were generated entirely from Scheimpflug data.[4] The system can measure 30000 points for the posterior corneal surface and 35632 points for the anterior corneal surface. The data from both corneal surfaces were then used to reconstruct a pachymetry map.[4]

CCT and minimum thickness were also measured and analyzed. Sirius gives a curvature map, as well as axial and tangential of the posterior and anterior surfaces, the pachymetric map and the global refractive corneal power. Three valid scans were performed for each examination session; after each acquisition, the device was moved backward and adjusted for the next scan to avoid dependency of the consecutive measurements and the total time for obtaining all measures did not exceed 10 minutes.

In this study, an imaging instrumentation AS-OCT system (Optovue Inc, Fremont, USA, California) with running software *(version A6)* was employed to measure corneal thickness in all patients involved in the study. Accurate fixation and centration of the subjects eyes were ensured for all subjects during examination. Each inspection took only a few seconds. During a single visit, the scan was performed three times for each eye.The resulting data comprised "corneal thickness, total corneal power and a profile of corneal epithelial thickness over a 6-mm-diameter corneal region" separated into three zones: central zone 2 mm, inner ring 2 to 5 mm (mid zone) and outer ring 5 to 6 mm (peripheral zone).

Data were analysed by using SPSS version 20.0 software. Kolmogorov-Smirnov test was used to confirm the normality of data. Data were expressed in mean ± SD, paired sample t-test and pearson's correlation wereused to compare the results. P value was considered to be significant if less than 0.05. The agreement between the two devices was achieved by using mean differences between the measurements and 95% limits of agreement which provided the interval within which 95% of the differences in measurements were supposed to be.

## RESULTS

For 200 subjects (a convenient sample) with meanage of 25.8 years, corneal topography and tomography data we recollectedfor further analysis. Data included in the comparison were represented in table 1.

Mean CCT by Sirius was 540.2 ± 27.9 µm and mean CCT by Optovue was 534.13 ± 27.91. Statistical

**Table 1:** *Demographic data of subjects.*

| Age Years (Mean ± SD) | 28.5±2.25 | Optovue | Sirius | p value |
|---|---|---|---|---|
| Female/male | 110/90 | / | / | / |
| UCVA LogMAR | 0.32 ± 0.50 | / | / | / |
| BCVA LogMAR | 94592 ± 0.12 | / | / | / |
| SE (Diopter) | 3.57 ±3.35 | / | / | / |
| CCT μm | / | 534.13 ±27.88 | 540.20 ± 27.85 | 0.00 |
| Minimum thickness μm | / | 526.79 ± 27.81 | 537.44 ± 27.56 | 0.002 |
| Corneal power (Diopter) | / | 43.440 ± 1.456 | 43.597 ± 1.408 | 0.00 |

"UCVA: uncorrected visual acuity, BCVA: best corrected visual acuity, SE: spherical equivalent, CCT: central corneal thickness, μm: micrometer".

analysis revealed significant difference existed between the mean CCT measured by the two devices (paired sample t-test). The mean difference was 6.07 (p value = 0.00) as in table 2.

95% limit of agreement (LOA) between the two devices was calculated by mean difference ± 1.96 multiplied by SD, regarding central corneal thickness LOA was between 18.99 and 6.85 and only four among 200 readings were out of limit as in figure1. There was a strong positive Correlation between themeasured mean CCT by the Optovue and Sirius with Pearson correlation = 0.972, p value = 0.000.

There was 526.79 ± 27.81 μm minimum corneal thickness by Optovue and 537.44 μm ± 27.56 by

**Table 2:** *The mean differences between Sirius and Optovue measurements.*

| Variable | Mean | SD | Lower Limit (LOA) | Upper LIMIT (LOA) | P – value |
|---|---|---|---|---|---|
| CCT | -6.0700 | 6.59260 | -18.9915 | 6.851496 | 0.000 |
| MCT | -10.6550 | 6.89374 | -24.1667 | 2.85673 | 0.002 |
| Net power | 0.1546 | 0.52531 | -0.87501 | 1.184208 | 0.000 |

CCT: Central corneal thickness and MCT:Minimum corneal thickness

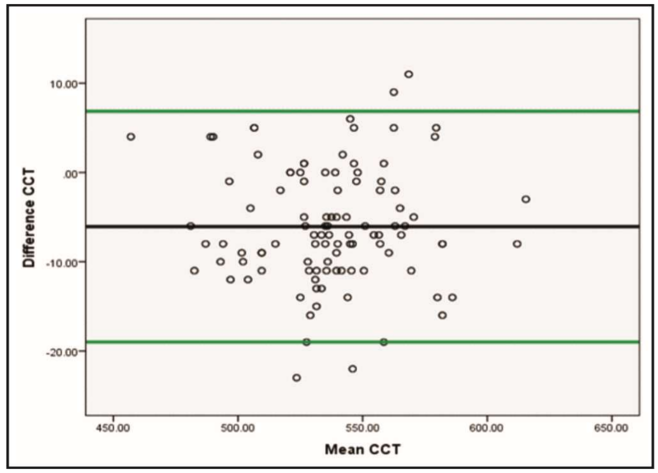


**Figure 1:** Scatter plot shows the variance between the mean CCT measurements by Optovue and Sirius.

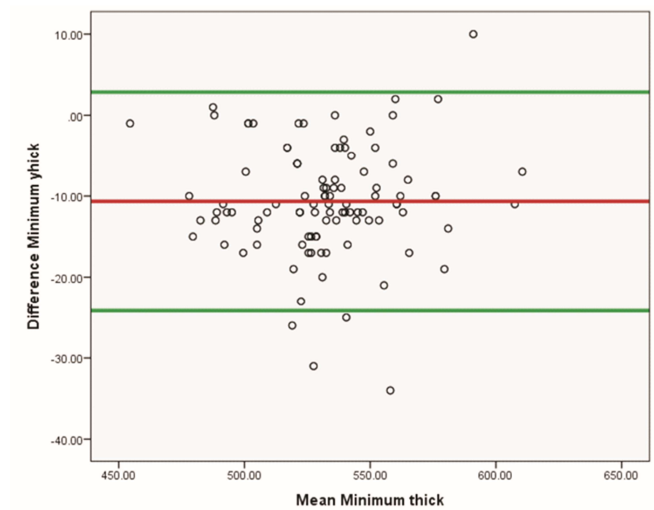


**Figure 2:** Scatter plot shows the variance between the mean minimum thickness measurement by Optovue and Sirius.

Sirius. The mean difference was10.65 μm ± 6.894 (p = 0.002). 95% limit of agreement (LOA) between the two devices regarding minimum thickness measurement was estimated by the same formula and was located between 24.16 and 2.85. Only five among 200 readings were out of limit as in figure 2. Strong positive correlation was seen between the measurements and Pearson correlation = 0.969, p value = 0.000.

The mean net power was 43.461 ± 1.452D by Optovue and 43.615 ± 1.403D by Sirius. The mean difference was -0.1545 ± 0.5253 with statistically significant difference between the two measurement p = 0.000. With 95% LOA between 0.87 and 1.8 and only 6 out of 200 readings out of the limit. Pearson correlation of mean k by Sirius and net power by OCT was 0.932, p value = 0.000. Figure 3 shows the difference between corneal power measurements between the two devices.

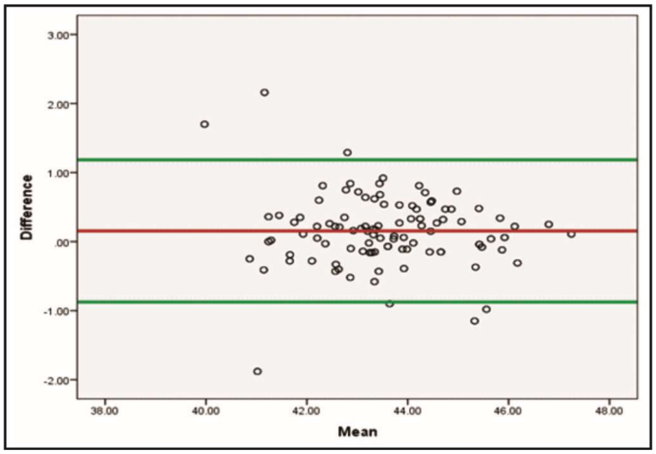


**Figure 3:** Scatter plot shows the variance between the mean net powers by Optovue and mean K by Sirius.

## DISCUSSION

Measurement of CCT can be helpful in many situations. For example, in the setting of acquiring intraocular pressure (IOP) accurate measurement, evaluation of corneal endothelial function and for assessing the patient's fitness for refractive surgery.[1] Ultrasound pachymetry is the gold standard for measuring CCT. However, the contact nature and the operator dependence nature of the device led to the fact that ophthalmologists are trying to compare the non-contact devices to the gold standard and testing their precision and repeatability.[1]

In the current study, two different non-contact devices were compared: Sirius topography and Optovue OCT. The results showed that CCT measured by Optovue was significantly lower than that of Sirius topography. The mean CCT by Sirius topography was 540.20 ± µm 27.85. The mean CCT by OCT was 534.13 ± 27.88 µm.

In our study the CCT measured by OCT was higher than the result from the Üçer MBstudy who used RTVue.[11] But it was lower than Khaja et al, study who used Heidelberg SL-OCT.[12] The mean of minimum corneal thickness by Sirius was comparable to other studies in literature.

The difference between CCT and thinnest corneal thickness by OCT was statistically significant. There was also an important difference between CCT and thinnest location determined by Sirius (p value = 0.00) so these two values cannot substitute each other.

Several published studies compared CCT measurement by OCT with ultrasound (US) device. CCT value was reported to be lower in OCT compared to US pachymetry. Ramesh et al,reported that mean CCT measured with OCTwas 16.14 µm lower than US pachymetry.[13] Northey et al, found 16µm lower CCT in OCT.[1] Garcia-Medina et al, discovered that CCT measured with OCT was 17 µm lower than US CCT.[1] Kan et al, found aless statistically significant difference between CCT measured by US pachymetry and OCT and the mean CCT values measured with US were 1.85 µm higher than those obtained from OCT.[1]

The higher CCT by US may be because of the use of topical anesthetic, the inability for accurately detecting the corneal center and the reflection of US wave from the descemet's membrane.

In several studies the CCT measurement by Sirius was higher than that obtained by US.[1-1]??? This difference might be because of corneal vertex as a reference center in Sirius, while the pupil is used as a center for probe position in the US.

OCT might be safest for estimating corneal thickness among non-contact devices, both for the central and the minimum thickness. This is due to the fact that the Scheimpflug–Placido topography measures corneal thickness between the air-tear film surface and the posterior corneal surface and the measurements are affected by tear-film quality.[2] Besides the fact that working principle is dependent on the reflectance of light beams and varies significantly from OCT systems with a faster scanning speed, which may overcome artifacts caused by eye movements.[21] These factors also explained why CCT by OCT yielded lower results than Sirius.

The net power in OCT measurement was significantly lower than Sirius mean K and wasalso lower than conventional standard keratometry. Therefore, itis not appropriate to use OCT-based power in the standard IOL calculation formula and it cannot substitute the mean K estimated by Sirius topography according to our result.

There are some limitations to this study. The measurement repeatability and reproducibility were not evaluated. However, previous studies have proved the great repeatability and reproducibility of these devices.

In addition, we did notassess CCT in subjects with corneal disorders such as keratoconus, post-refractive surgery and post-contact lens usage. The outcomes in this patient population may differ.

**Conflict of Interest:** Authors declared no conflict of interest.

**Ethical Approval:** The study was approved by the Institutional review board/Ethical review board **(Al Kindy College of medicine IRB No 194).**

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## Authors' Designation and Contribution

Suzan Amana Rattan; *Assistant Professor: Concepts, Literature Search, Data Acquisition, Data Analysis, Statical Analysis, Manuscript Preparation, Manuscript Editing, Manuscript Review.*

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