Corneal thickness, curvature, and elevation readings in normal corneas: Combined Placido–Scheimpflug system versus combined Placido–scanning-slit system

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PURPOSE: To evaluate agreement in central corneal thickness (CCT), keratometry, and anterior and posterior elevation map measurements in normal corneas between a combined Placido–Scheimpflug system and a combined Placido–scanning-slit elevation topography system.

SETTING: Department of Cataract & Refractive Surgery, Rothschild Foundation, Paris, France.

DESIGN: Evaluation of diagnostic test or technology.

METHODS: Measurements were performed with a combined Placido–Scheimpflug system (TMS-5) and a combined Placido–scanning-slit system (Orbscan II). Ultrasound (US) pachymetry was used as the reference for CCT measurements. Bland-Altman plots were used to evaluate agreement between instruments.

RESULTS: The mean CCT measurements by US pachymetry, the Placido–Scheimpflug system, and the Placido–scanning-slit system were 556.74 μm $\pm$ 42.45 (SD), 543.23 $\pm$ 36.73 μm, and 564.45 $\pm$ 41.26 μm, respectively. Although the CCT readings were statistically significantly thinner with the Placido–Scheimpflug system than with the other systems, there was high correlation between instruments. Peripheral corneal thickness readings were also thinner with the Placido–Scheimpflug system than with the Placido–scanning-slit system. Keratometry and anterior and posterior best-fit sphere (BFS) measurements were comparable between the 2 optical devices. Anterior and posterior maximum central elevations measured by the 2 instruments were not comparable or strongly correlated. Repeatability after 3 successive measurements was excellent for all parameters except maximum central elevation.

CONCLUSIONS: Although highly correlated, with corneal thickness readings were not interchangeable between the 2 optical devices. No statistically significant differences in keratometry or BFS measurements were observed between the 2 devices. There were important discrepancies in the maximum central elevation between the 2 topographers.

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Corneal thickness and curvature measurements are highly important in refractive surgery. Patient eligibility, choice of surgical technique, risk for late complications,[1–3] and the amount of ablation depend on accurate analysis of corneal topography. These parameters are also important for the diagnosis of corneal ectasia (eg, keratoconus) and in glaucoma pathology because a variation in corneal thickness affects the accuracy of applanation tonometry.[4] In addition, high repeatability with low variation between examinations is essential to monitor the evolution in a patient's cornea over time.

The widely used Orbscan II system (Bausch & Lomb), which combines a Placido disk with scanning-slit topography, has become the reference for many refractive surgeons over the past decade.[5–8] Although the Placido disk allows accurate analysis of corneal surface curvature, the scanning-slit analyzes the posterior surface, providing topography of the anterior and posterior surfaces as well as corneal thickness maps.

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The recently introduced TMS-5 topographer (Topographic Modeling System, version 5, Tomey Corp.) uses a rotating Scheimpflug system in addition to the Placido disk; earlier versions used the Placido disk alone. Unlike the Pentacam (Oculus Optikgeräte GmbH), which is solely a Scheimpflug-based system that derives keratometry data of the surface from the Scheimpflug images (providing up to 25 000 data points), the TMS-5 system obtains that data by merging Placido-ring topography (up to 7300 data points) and Scheimpflug topography (up to 40 960 data points).

A handheld ultrasound (US) pachymeter is often used as a reference for central corneal thickness (CCT) determination.[9–12] However, this method has several disadvantages that may limit its accuracy and clinical use. These include the need for topical anesthesia, contact between a probe and the cornea with the associated risk for epithelial damage and infection, and inaccurate measurements if the probe is placed slightly off center or is not placed 90 degrees to the corneal surface.

The purpose of this study was to compare keratometry (K) and pachymetry readings, the best-fit sphere (BFS), and the maximum elevation point in a 3.0 mm central zone calculation with the new TMS-5 topographer and the Orbscan II topographer. Repeatability of measurements was also studied. The CCT measurements were further compared with those of US pachymetry.

PATIENTS AND METHODS

Patients were recruited prospectively from the Department of Refractive Surgery, Rothschild Ophthalmic Foundation, Paris, France. Exclusion criteria were previous ocular surgery or ocular pathology other than refractive error. The local ethics committee approved this study, which followed the tenets of the Declaration of Helsinki.

Contact lens wearers were asked not to wear the lenses for 72 hours before the measurements were taken. Each patient had measurements with the TMS-5 Placido–Scheimpflug system, the Orbscan II Placido–scanning-slit system, and a US pachymeter (SP-100, Tomey Corp.). All measurements were taken at the same time of day (between 10 AM and 6 PM) and at least 3 hours after wakeup time to avoid the effects of diurnal variation in corneal thickness.[13] Both eyes of each patient were used for statistical analysis because eyes were not compared with each other.

Corneal Topography

Examinations of each patient started with the Placido–Scheimpflug system and the Placido–scanning-slit system, both of which are noncontact methods. With both systems, the patient's chin was placed on the chin rest and the forehead was pressed against the forehead strap. The patient's eye was then aligned along the visual axis by a central fixation light. For the Placido–scanning-slit system, the distance between the corneal apex and the center of the moving slit was adjusted manually with the help of 2 reflected and inverted half circles. The default 0.92 acoustic correction factor was applied for CCT readings as recommended by the manufacturer.

With the Placido–Scheimpflug system, the examiner sees a real-time image of the patient's eye on the topographer's screen. For each eye, 2 acquisitions are necessary. The system initially takes 4 measurements using Placido-ring topography (Ring Topo Mode), with each measurement lasting less than 0.5 seconds. The operator then retracts the joystick fully and activates the Scheimpflug system (slit mode) and the Scheimpflug acquisition is performed. In each case, the patient was asked to keep still and keep his or her eye open. The image was focused and centered, after which the software automatically began taking the measurements.

A trained operator performed the examinations using both devices in random order. Three maps were acquired for each topographer.

Raw data were extracted using Orbscan II Data Recorder software (Bausch & Lomb) and the Data Table Tool of the Tomey ExamViewer software (Tomey Corp.). Corneal thickness was assessed in 10 reference positions: central, superior, nasal superior, nasal, nasal inferior, inferior, temporal inferior, temporal, temporal superior, and thinnest point. Peripheral corneal thicknesses were obtained 2.5 mm from the center of the topography.

Ultrasound Pachymetry

The CCT was then measured using the US pachymeter after instillation of a drop of oxybuprocaine 1.0% in each eye. The pachymeter was calibrated at the beginning of each reading. The US probe was gently applied as perpendicularly as possible on the center of the cornea while the patient was instructed to fixate on a distant target. The mean of 8 measurements was calculated. The same operator performed all US pachymetry measurements.

Statistical Analysis

The main outcome measure was the CCT obtained with the 2 optical systems and compared with US pachymetry readings. Also compared with the 2 optical systems were the peripheral pachymetry, K readings (flat axis, steep axis, mean keratometric astigmatism), elevation (anterior and posterior BFS, maximum difference in elevation between the BFS (at 10.0 mm diameter) and the patient's cornea in a 3.0 mm central zone for both anterior and posterior elevation.

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Table 1. Mean CCT readings.

	Central Corneal Thickness (μm)		
Value	Placido–Scheimpflug	Placido–Scanning Slit	US pachymetry
Mean ± SD	543.23 ± 36.73	564.45 ± 41.26	556.74 ± 42.45
Range	463.00, 624.67	454.54, 631.19	446.00, 649.00
95% CI	534.20, 552.26	554.30, 574.59	546.31, 567.18

CCT = central corneal thickness; CI = confidence interval; US = ultrasound

Differences between the devices were assessed using the paired Student *t* test. Pearson correlation coefficients were determined to show the correlations between data. The Bland-Altman method was used to assess the agreement in variables between the 2 devices, and the 95% limits of agreement (LoA) were calculated. Data are presented as the mean ± standard deviation. A *P* value less than 0.05 was considered significant. Repeatability was assessed using intraclass correlation coefficients (ICCs).

All data were analyzed using SPSS software (version 19, SPSS, Inc.) and MedCalc (version 11.6.0.0, MedCalc Software bvba, Inc.).

RESULTS

Sixty-six eyes of 33 patients (16 men, 17 women) were included. The mean age was 33.9 ± 12.7 years (range 19 to 63 years).

Corneal Thickness

Table 1 shows the mean CCT readings and Table 2, the interdevice differences. The CCT measurements were significantly thinner with the Placido–Scheimpflug system than with the Placido–scanning-slit system and the US pachymeter (mean difference 21.21 ± 11.95 μm and 13.51 ± 11.16 μm, respectively); the difference was higher in patients with thick corneas (Figures 1 to 3). Linear regression showed that all 3 modalities of CCT measurements were strongly correlated with each other.

Compared with Placido–scanning-slit measurements, the Placido–Scheimpflug system significantly underestimated the thinnest point and peripheral pachymetry (mean difference 11.60 ± 13.52 μm for temporal reading and 24.67 ± 10.97 μm for nasal-inferior reading) (Tables 3 and 4). Results with the 2 devices correlated closely, with Pearson correlation coefficients ranging from 0.955 to 0.973.

Keratometry

There was no statistically significant difference in the steep K axis, flat K axis, or keratometric astigmatism readings between the 2 optical devices. Moreover, the correlation between the devices was excellent (Figure 4).

Elevation

No statistically significant difference was observed for anterior or posterior BFS measurements between the 2 optical devices. The 95% LoA calculation showed a narrower range for anterior BFS (−0.10 to 0.12) than for posterior BFS (−0.19 to 0.17). Anterior and posterior maximum elevations measured by the 2 devices were neither comparable nor strongly correlated (Figure 5).

Repeatability

Agreement of 3 successive measurements performed during the same visit was excellent for both systems for pachymetry (ICC 0.953 to 0.974 for Placido–Scheimpflug system and 0.962 to 0.984 for Placido–scanning-slit system), K readings (0.972 to 0.992 and 0.981 to 0.985, respectively), anterior BFS calculation (0.993 and 0.992, respectively), and posterior BFS calculation (0.990 and 0.990, respectively). On

Table 2. Interdevice comparison of CCT measurements.

	Difference of Mean		Pearson Correlation		95% LoA	
Device Pairing (A and B)	Δ ± SD (μm)	*P* Value	*R* Value	*P* Value*	Lower (μm)	Upper (μm)
Placido–scanning slit and US	7.70 ± 10.34	<.001	0.970	<.001	−12.6	28.0
Placido–scanning slit and Placido–Scheimpflug	21.21 ± 11.95	<.001	0.960	<.001	−2.2	44.6
Placido–Scheimpflug and US	−13.51 ± 11.16	<.001	0.971	<.001	−35.4	8.4

Δ = A − B = mean interdevice difference; LoA = limits of agreement; US = ultrasound
*2 tailed

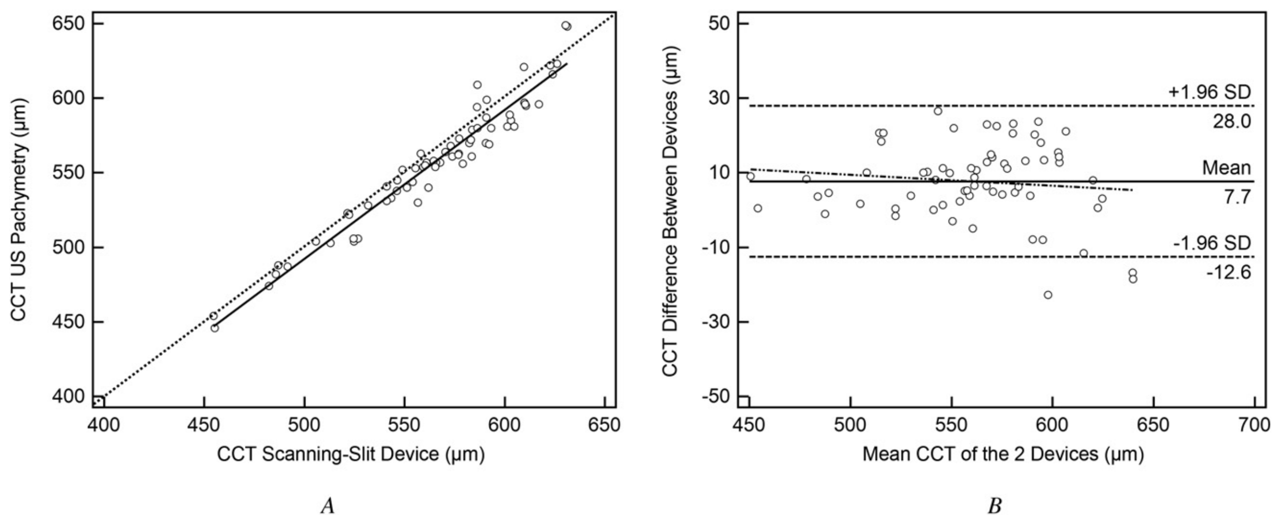

Figure 1. Central corneal thickness with the Placido–scanning-slit system versus US pachymetry. *A*: Scatterplot. *B*: Bland-Altman plot (CCT = central corneal thickness; US = ultrasound).

the other hand, repeatability was lower for maximum anterior elevation (0.695 and 0.762, respectively) and for maximum posterior elevation (0.670 and 0.779, respectively).

DISCUSSION

The recently introduced TMS-5 system is a major upgrade over previous versions. It uses a rotating Scheimpflug system in addition to the Placido disk, allowing analysis of the corneal posterior surface as well as anterior surface. To our knowledge, this is the first study comparing this new topography device with the Orbscan II scanning-slit topographer and US pachymetry, the latter being used as a reference for CCT measurements.

The accuracy of corneal thickness measurements is important in determining eligibility for refractive surgery and the amount of correction that can safely be performed. Underestimating corneal thickness may cause eligible patients to be excluded for refractive procedures, whereas overestimation may lead to overablation, thereby increasing the risk for iatrogenic keratectasia.

We decided to use US pachymetry as the reference for CCT measurement in our study because new topography devices are calibrated against the US pachymeter. However, as Bourne and McLaren[14] point out, the most accurate pachymetry measurements can be obtained with optical pachymeters, such as the one described by Maurice and Giardini.[15] Nevertheless, ultrasonic pachymeters are fast, simple to use, and

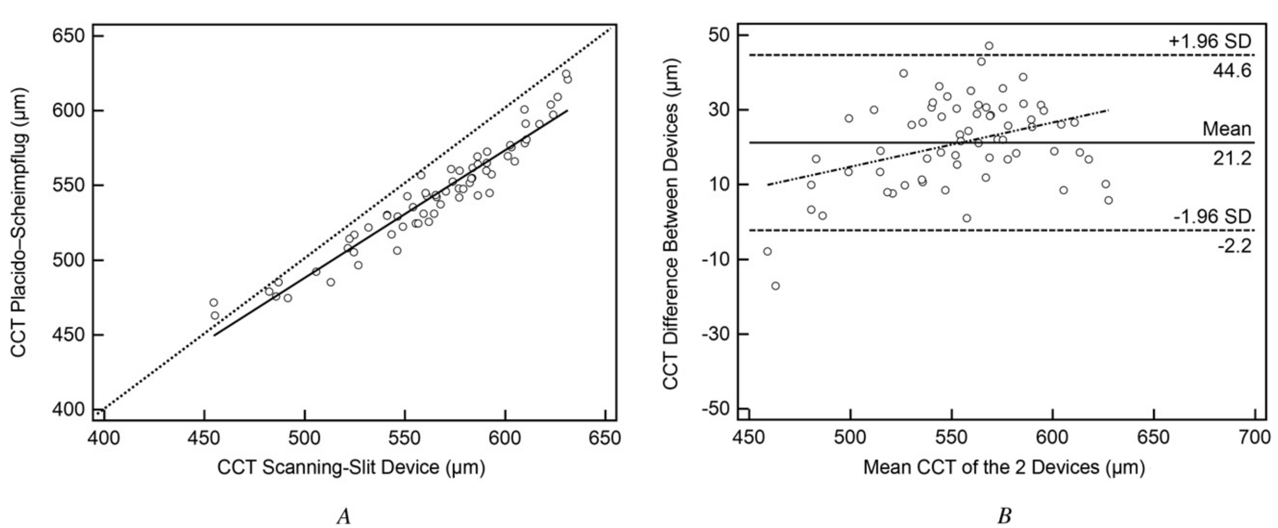

Figure 2. Central corneal thickness with the Placido–scanning-slit system versus the Placido–Scheimpflug system. *A*: Scatterplot. *B*: Bland-Altman plot (CCT = central corneal thickness).

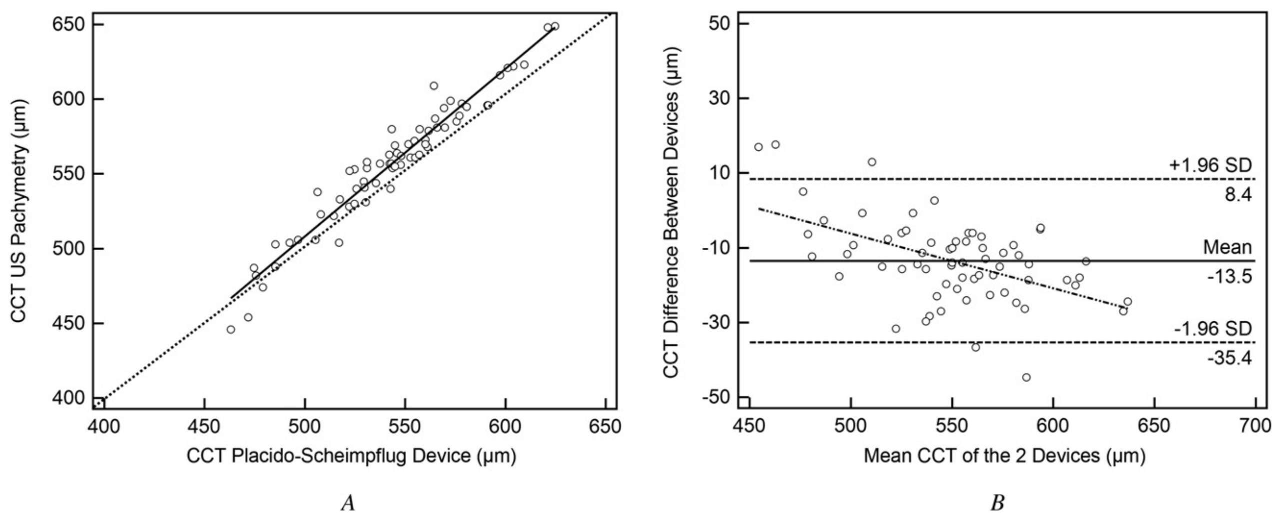

Figure 3. Central corneal thickness with the Placido–Scheimpflug system versus US pachymetry. *A*: Scatterplot. *B*: Bland-Altman plot (CCT = central corneal thickness; US = ultrasound).

widely available, and they provide repeatable measurements, explaining why many recent studies use this method as a reference.[16–18]

Despite a strong correlation, a significant difference in CCT measurements was observed between the 3 devices. Most studies used a default acoustic correction factor value of 0.92 for Orbscan pachymetry reporting[5,6,9,17,19–21] and found good agreement between handheld US pachymetry and Orbscan measurements.[5,7,11,20] However, others found that the devices should not be used interchangeably.[17,21–24] In our study, using the Orbscan II with the 0.92 acoustic correction factor resulted in CCT values that were very similar to readings obtained with a high-precision 50 MHz US pachymeter. Although the difference between CCT readings obtained by the US pachymeter and the Orbscan II device was statistically significant, the absolute difference of −12.6 to 28.0 μm is comparable to the range of ±11 μm to ±18 μm reported for the diurnal variation in CCT.[13,25]

Table 3. Mean Placido–Scheimpflug and Placido–scanning-slit readings for thinnest point, peripheral corneal thickness, K, and elevation.

	Placido–Scheimpflug		Placido–Scanning Slit	
Parameter	Mean ± SD	95% CI	Mean ± SD	95% CI
Pachymetry (position)				
Thinnest point (μm)	538.29 ± 36.88	529.22, 547.35	557.76 ± 43.30	547.12, 568.41
Superior (μm)	609.74 ± 45.25	598.61, 620.86	629.10 ± 45.89	617.73, 640.47
Nasal superior (μm)	607.50 ± 42.63	597.02 -617.98	631.53 ± 43.39	620.86, 642.20
Nasal (μm)	602.41 ± 39.21	592.77, 612.05	618.74 ± 40.88	608.69, 628.79
Nasal inferior (μm)	590.51 ± 37.93	581.19, 599.84	615.18 ± 39.92	605.36, 624.99
Inferior (μm)	585.17 ± 38.79	575.64, 594.71	600.99 ± 39.42	591.23, 610.76
Temporal inferior (μm)	569.03 ± 39.13	559.41, 578.65	590.63 ± 42.30	580.23, 601.03
Temporal (μm)	570.27 ± 41.14	560.16, 580.39	581.87 ± 45.94	570.58, 593.16
Temporal superior (μm)	586.49 ± 43.53	575.79, 597.19	608.79 ± 46.19	597.44, 620.15
Keratometry				
Kf (D)	42.34 ± 1.60	41.95, 42.73	42.40 ± 1.67	42.00, 42.82
Ks (D)	43.28 ± 1.61	42.88, 43.67	43.35 ± 1.64	42.95, 43.76
Astigmatism (D)	0.94 ± 0.71	0.76, 1.11	0.95 ± 0.70	0.78, 1.12
Elevation				
Anterior BFS (mm)	8.06 ± 0.30	7.99, 8.13	8.07 ± 0.29	8.00, 8.14
MAE (μm)	6.51 ± 1.67	6.10, 6.92	12.16 ± 3.83	11.22, 13.10
Posterior BFS (mm)	6.74 ± 0.27	6.67, 6.81	6.73 ± 0.31	6.65, 6.81
MPE (μm)	12.17 ± 2.83	11.48, 12.87	25.66 ±8.34	23.61, 27.71

BFS = best-fit sphere; CI = confidence interval; Kf = keratometry in flat axis; Ks = keratometry in steep axis; MAE = maximum anterior elevation in a central 3.0 mm zone; MPE = maximum posterior elevation in a central 3.0 mm zone

Table 4. Placido–Scheimpflug minus Placido–scanning-slit difference in thinnest point, peripheral corneal thickness, K, and elevation measurements.

	Difference of Mean		Pearson Correlation		95% LoA	
Parameter	Δ ± SD (μm)	*P* Value	*r* Value	*P* Value*	Lower	Upper
Pachymetry (position)						
Thinnest point (μm)	−19.47 ± 13.64	<.001	0.955	<.001	−46.2	7.3
Superior (μm)	−19.37 ± 13.36	<.001	0.957	<.001	−45.6	6.8
Nasal superior (μm)	−24.03 ± 12.04	<.001	0.961	<.001	−47.6	−0.4
Nasal (μm)	−16.33 ± 11.42	<.001	0.960	<.001	−38.7	6.0
Nasal inferior (μm)	−24.67 ± 10.97	<.001	0.962	<.001	−46.2	−3.2
Inferior (μm)	−15.87 ± 10.30	<.001	0.966	<.001	−36.1	4.3
Temporal inferior (μm)	−21.60 ± 10.04	<.001	0.973	<.001	−41.3	−1.9
Temporal (μm)	−11.60 ± 13.52	<.001	0.958	<.001	−38.1	14.9
Keratometry						
Kf (D)	−0.07 ± 0.36	.123	0.977	<.001	−0.77	0.63
Ks (D)	−0.08 ± 0.38	.096	0.973	<.001	−0.82	0.66
Astigmatism (D)	−0.01 ± 0.09	.377	0.992	<.001	−0.19	0.17
Elevation						
Anterior BFS (mm)	−0.01 ± 0.06	.126	0.982	<.001	−0.12	0.10
MAE (μm)	−5.65 ± 3.64	<.001	0.332	.006	−12.8	1.5
Posterior BFS (mm)	0.01 ± 0.09	.439	0.959	<.001	−0.17	0.19
MPE (μm)	−13.49 ± 7.97	<.001	0.295	.016	−29.1	2.1

Δ = mean interdevice difference; BFS = best-fit sphere; Kf = keratometry in flat axis; Ks = keratometry in steep axis; LoA = limits of agreement; MAE = maximum anterior elevation in a central 3.0 mm zone; MPE = maximum posterior elevation in a central 3.0 mm zone
*2 tailed

The CCT readings with the TMS-5 system were lower than those obtained with US pachymetry and the Orbscan II device, with a statistically significant mean difference of 13.51 ± 11.16 μm and 21.21 ± 11.95 μm, respectively. The Bland-Altman plots show that the 95% LoA (mean difference ± 1.96 SD) for CCT measurements between the Placido–Scheimpflug system and US pachymetry ranged from −35.4 μm to 8.4 μm, meaning that the Placido–Scheimpflug system measurements could be as much as 35.4 μm lower than the US pachymeter values. These discrepancies are likely to be clinically significant, especially in patients having refractive procedures, for whom readings obtained with the 2 devices cannot be used interchangeably. However, the correlation between the Placido–Scheimpflug CCT readings and the Placido–scanning-slit and US pachymeter CCT measurements was excellent. The

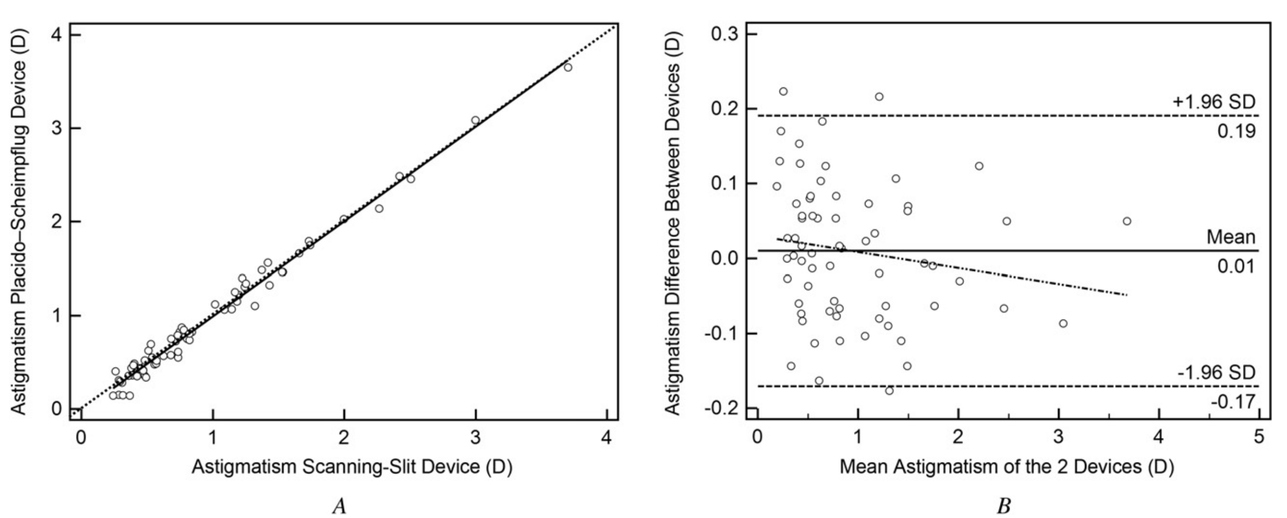

Figure 4. Keratometric astigmatism with the Placido–scanning-slit system versus the Placido–Scheimpflug system. *A*: Scatterplot. *B*: Bland-Altman plot.

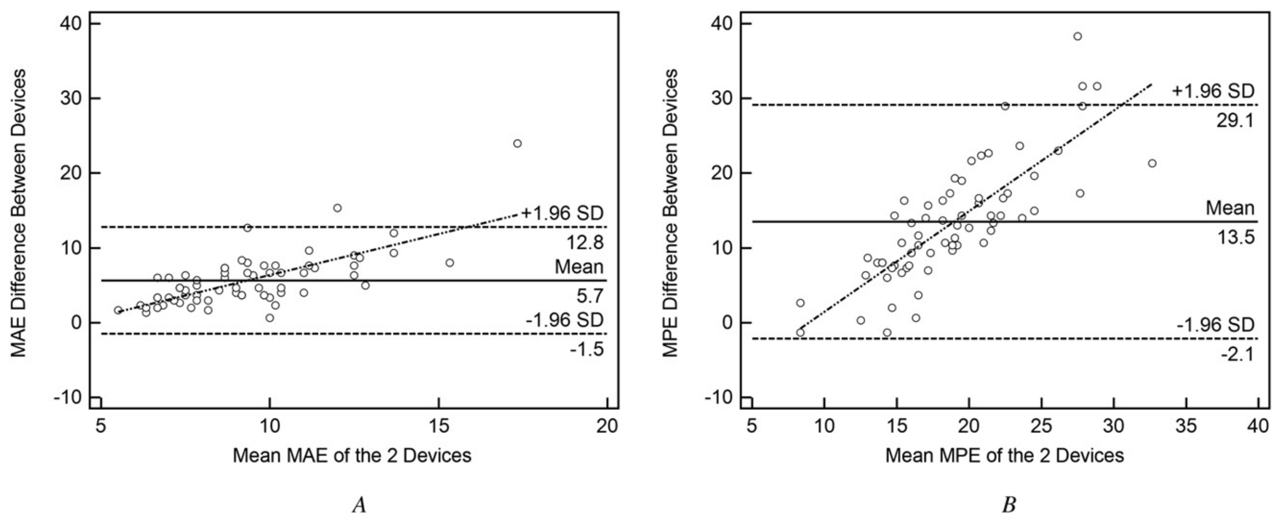

Figure 5. Bland-Altman plots of maximum central elevation readings with the Placido–scanning-slit system versus the Placido–Scheimpflug system. *A*: Anterior. *B*: Posterior (MAE = maximum anterior elevation; MPE = maximum posterior elevation).

Bland-Altman plots for comparisons of the Placido–Scheimpflug system and the US pachymeter show the amount by which the CCT measurements disagreement varies with the actual thickness measurement. Therefore, it may allow an appropriate conversion equation to be calculated so that readings from the 2 devices can be interchangeable.

The TMS-5 system uses a Placido disk in addition to the Scheimpflug system to improve topographic analyses of the anterior surface, whereas the Pentacam system derives curvature analysis from only the Scheimpflug images. Bourges et al.[17] report slightly thinner CCT readings with the Pentacam device than with US pachymetry, with a mean difference of −15.2 μm. Hashemi and Mehravaran[16] found similar results. Both are in good agreement with the TMS-5 CCT measurements in our study. Thus, this indirect comparison shows that CCT measured by the TMS-5 and Pentacam systems may be similar. A recent study comparing anterior segment measurements by 3 Scheimpflug tomographers and 1 Placido corneal topographer found a statistically significant difference but a relatively small 95% LoA (from −0.74 to +0.28 D) in mean simulated K readings between the Pentacam and TMS-5 systems. Concerning thinnest-point readings, there was no statistically significant difference between the Pentacam and TMS-5 systems, with a relatively narrow 95% LoA between the 2 (from −41.19 to +6.71 μm).[26] These results confirm that measurements obtained with the 2 devices may be close but cannot be used interchangeably.

As for CCT readings, the peripheral corneal thickness and thinnest-point readings were thinner with the Placido–Scheimpflug system than with the Placido–scanning-slit system, with the mean differences ranging from 11.60 ± 13.52 μm (inferior) to 24.67 ± 10.97 μm (nasal–inferior). For the nasal–superior readings, the 95% LoA ranged from 0.4 to 47.6 μm, meaning that for this corneal position, measurements obtained with the Placido–Scheimpflug system could be as much as 47.6 μm lower than those obtained with the Placido–scanning-slit system. This clinically significant difference in peripheral corneal thickness evaluation between the 2 devices shows that the measurements of the 2 instruments are not interchangeable. The devices use different principles of optical measurement. The Orbscan II system uses a scanning slit to analyze the posterior surface, whereas the TMS-5 system uses a rotating Scheimpflug camera. This may partly explain the differences between the 2 devices because more data have to be interpolated in the periphery than in the center with a rotating camera. This is in contrast to a scanning slit, which evenly scans the whole cornea.

Keratometry readings in both meridians were slightly flatter with the Placido–Scheimpflug system than with the Placido–scanning-slit system. However, the difference did not reach statistical significance and would have no clinical relevance because it is far below the reported diurnal keratometric fluctuations.[13,27] The mean difference in keratometric astigmatism measurements between the 2 devices was close to zero, and the correlation was almost perfect.

The Placido coverage of the TMS-5 is larger because the system uses a full small cone with 31 uninterrupted Placido rings (maximum ring diameter 11.7 mm), which distance to the corneal apex is less than 2.0 cm during acquisition, whereas the Orbscan uses a larger distant Placido disk that is truncated superiorly and inferiorly. Thus, if the area covered by the Orbscan

II system horizontally (<10.0 mm) is close to that obtained by the TMS-5 system, this is not the case vertically (<6.0 mm for the Orbscan). Therefore, we limited our objective analysis to data obtained in the paracentral area. However, the larger coverage of the TMS-5 system may provide clinicians with broader curvature information.

Regarding elevation measurements, no statistically significant difference was observed in anterior or posterior BFS readings between the 2 systems. The maximum anterior elevation and maximum posterior elevation had higher values with the Placido–scanning-slit system by 5.65 ± 3.64 μm and 13.49 ± 7.97 μm, respectively. Although the anterior and posterior BFS readings by the 2 instruments were strongly correlated, no such correlation was found for the maximum anterior elevation and maximum posterior elevation. Higher positioning of the BFS by the TMS-5 software than by the Orbscan II software may explain the discrepancy between the 2 devices. Evaluating agreement between the Pentacam and the Orbscan II systems, Ha et al.[28] found that the posterior elevation values measured using the Orbscan II system were greater than those measured using the Pentacam system ($P < .001$). Karimian et al.[29] found similar results comparing the Orbscan II system and Galilei system (Ziemer Ophthalmic Systems AG), with the former yielding higher anterior and posterior maximum elevation results by approximately 6.0 μm and 27.0 μm, respectively. From these observations, it can be concluded that the Orbscan II system tends to yield higher elevation results, especially for the posterior corneal surface, than other imaging systems with the capability of evaluating the posterior curvature (eg, TMS-5, Pentacam, Galilei).

A reliable topographer should provide low variations between repeated measurements. In our study, the low variation between 3 successive measurements by the same examiner using the Orbscan II and TMS-5 pachymetry and K readings is important because these technical examinations are often delegated to nonmedical personnel. In this context, it might be interesting to study interoperator reproducibility and reproducibility over time, as Bourges et al.[17] did for CCT and peripheral corneal thickness with the Orbscan II and Pentacam devices. They found that interoperator reproducibility and reproducibility over time were almost perfect for both systems. On the other hand, we observed that the repeatability of anterior and posterior maximum elevation readings was low for the Orbscan II system (ICC value 0.762 and 0.779, respectively) and even lower for the TMS-5 system (ICC value 0.695 and 0.670, respectively). Therefore, caution should be taken, especially with posterior maximum elevation readings because this value is useful in screening for forme fruste keratoconus.[30,31]

One limitation of our study is that we did not compare representations of corneal topography between the 2 systems. Indeed, comparing topography maps is subject to many confounding parameters because of the subjective interpretation and variants, such as the colors used in the scale, the width of the scale, and the Placido coverage. Even if the 2 topographers have adjustable scales, a comparison based on visual inspection remains subjective, and more important, it cannot be used to compare the 2 devices and evaluate their reproducibility using objective statistical methodology. We used objective metrics to provide more comparable quantitative data.

Another limitation of our study is that our comparison was restricted to normal eyes. Before taking the measurements in a diseased cornea, validation of the values in a normal, healthy cornea is essential. For this reason, we believe that the present study, although limited to normal corneas, provides interesting and new information because to our knowledge, no previous published study has compared the TMS-5 system and the Orbscan II system. However, results may be different in patients with corneal pathology (eg, keratoconus, corneal scar) or after refractive surgery. A similar study should therefore be performed in such patients to evaluate the accuracy of TMS-5 system under these conditions.

WHAT WAS KNOWN

- Reliable corneal topographers providing accurate and highly repeatable measurements are essential in refractive surgery.
- The recently introduced TMS-5 represents a major upgrade over previous versions, adding a rotating Scheimpflug system in addition to the Placido disk, while earlier versions used the Placido disk alone. This new device has not yet been compared with the widely used Orbscan II.

WHAT THIS PAPER ADDS

- Like the Orbscan II, the TMS-5 provides highly repeatable pachymetry and keratometry measurements.
- Although pachymetry readings obtained with TMS-5 are strongly correlated to those obtained with Orbscan II, the devices are not interchangeable regarding pachymetry measurements. Keratometry readings obtained with the 2 devices are very similar.

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