Dependability of Pachymetry Measurements after Myopic Advanced Surface Ablation Using Scanning-Slit Topography and Specular Microscopy

Alberto López-Miguel, Loreto Martínez-Almeida, María Eugenia Mateo, María Begoña Coco-Martín, Jorge L. Alió, and Miguel J. Maldonado

PURPOSE. To assess the repeatability, interobserver reproducibility, and agreement of central corneal thickness (CCT) measurements obtained by scanning-slit topography (SST) and noncontact specular microscopy (NCSM) after advanced surface ablation (ASA).

METHODS. To analyze repeatability, one examiner measured 65 post-myopic ASA eyes five times successively using both techniques randomly. To calculate interobserver reproducibility a second examiner obtained another CCT measurement in a random fashion. To study interobserver reproducibility, the first operator obtained CCT measurements from another 24 eyes during two sessions 1 week apart.

RESULTS. With regard to intrasession repeatability, SST and NCSM within-subject standard deviation (Sw) and intraclass correlation coefficient (ICC) were 7.35 and 3.81, respectively. For interobserver reproducibility, SST measurement variability showed correlation with CCT magnitude (r = 0.38, P = 0.002), whereas NCSM did not. NCSM Sw and ICC were 3.83 μm and 0.99, respectively. For interobserver reproducibility, no difference in CCT measurements was found for any technique; Sw and ICC estimates for SST and NCSM were 12.2 and 8.37 μm, and 0.94 and 0.95, respectively. We found a tendency for the difference (mean SST-NCSM = 13.39 μm) to increase in thicker corneas (r = 0.45, P = 0.001).

CONCLUSIONS. Both noncontact pachymetry techniques provided highly repeatable and quite reproducible CCT measurements in post-ASA patients having no clinically significant corneal haze, except for SST interobserver reproducibility, which decreased in thinner corneas. However, the techniques were not interchangeable. The estimates provided should help clinicians differentiate real CCT change from noncontact pachymetry measurement variability after ASA. (Invest Ophtalmol Vis Sci. 2013;54:1054–1060) DOI:10.1167/iovs.12-11015

Excimer laser keratorefractive surgery is the most popular procedure worldwide for correcting refractive errors. Advance surface ablation (ASA) procedures have gained popularity because preoperative central corneal thickness (CCT), and especially residual stromal bed thickness, have been stated as major risk factors for a patient to develop ectasia after laser vision correction.1, 2 Therefore, taking into account the increasing number of patients undergoing ASA, reliable CCT measurements are mandatory when counseling patients for post-ASA enhancements,3 determining intraocular pressure for ocular hypertension and glaucoma diagnosis,4 and also calculating the power of pseudophakic intraocular lens after corneal laser photoablation.5

Ultrasonic (US) pachymetry has been the most commonly used method for measuring CCT and is still considered the gold standard.6 However, the US technique has some shortcomings related to probe contact with the cornea, like the need for using topical anesthesia and the risk of corneal epithelial damage or infection.6 In addition, US accuracy is highly examiner dependent because of probe misplacement and corneal compression, reducing its appropriateness in post-ASA patients.7 Therefore, clinicians are increasingly demanding noncontact pachymetry techniques able to provide reliable data.

Combined scanning-slit and placid-disk topography is a noncontact technique that provides full pachymetry mapping of the cornea. The scanning-slit topography (SST) shows lower measurement consistency in corneas having haze because the light slits traveling through the cornea may change direction resulting in variations in posterior surface data. Consequently, pachymetry analysis might be affected when there is loss of corneal transparency,8, 9 which is more likely to happen in post-ASA corneas than in post-LASIK ones.10 Besides, SST is currently the second topography system most used among refractive surgeons (Duffey RJ, Leaming DV, personal communication, 2011), thus, knowing its CCT dependability after ASA is mandatory nowadays.

Noncontact specular microscopy (NCSM) is an optical technique widely used in the daily clinic to assess corneal endothelial cell density for diagnosing corneal anomalies.11 In addition, it also provides CCT, whose reported measurement reliability is higher than US in healthy corneas12; hence, it could be also a valuable pachymetry device during post-ASA follow-up, taking into account that it might not be affected by minor media opacities.

The CCT measurement accuracy (systematic error related to the gold standard) of SST compared to US during the early and late post–myopic ASA period has been already established.13, 14 However, to our knowledge, its measurement reliability (random error) has been reported only after myopic LASIK15, thus, there is an absence of information regarding the precision of this technique in post–myopic ASA patients. Consequently,

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the main aim of the present study was to estimate the CCT measurement reliability (intrasession repeatability and inter- session and interobserver reproducibility) of SST in the absence of clinically significant haze after myopic ASA, and evaluate its interchangeability with NCSM following bland and Altman recommendations.16–18

**Methods**

The present study was approved by University of Valladolid Medical School Ethics Committee and adhered to the tenets of the Declaration of Helsinki. All enrolled subjects were informed of the nature of the study and consent forms were signed.

Patients were recruited over a 9-month period. Exclusion criteria consisted of suspected keratocoe, clinically significant lens opacity, active ocular disease, connective tissue disorders, and pregnancy or breastfeeding: in addition, patients included had to have post-ASA maximum corrected visual acuity ≥20/20 and clinically insignificant corneal haze. All eyes underwent a complete ophthalmic examination before ASA, including manifest and cycloplegic refractions, Orbscan-II topography, noncontact specular pachymetry, slit-lamp microscopy, applanation tonometry, and indirect ophthalmoscopy.

**Surgical Procedures**

All procedures were performed by the same surgeon (MJM). The details of the primary ASA procedures were as follows. The visual axis was first marked, and epithelial delamination was obtained using diluted 20% ethanol, which was applied to the surface of the cornea with a 9-mm Camellin-style LASEK trephine and alcohol well (Katena Products, Inc., Denville, NJ). After 30 seconds, the ethanol was washed off using a surgical sponge (Medtronic Ophthalmics, Jacksonville, FL) and chilled balanced salt solution. Epithelial flaps were always discarded. Laser ablation was performed using the Allegretto 400 Wave Eye-Q laser platform (Alcon Laboratories, Inc., Fort Worth, TX), and the cornea was chilled with cold balanced salt solution at the end of the procedure. Postoperatively, a therapeutic bandage contact lens were always worn (Acuvue Advance; Johnson & Johnson Vision Care, Inc., Jacksonville, FL) until the epithelium was healed, which usually occurred around 4 to 5 days after the surgical procedure. All ASA procedures were uneventful. Patients were examined postoperatively at 1 and 6 days and 1, 3, and 6 months.

**Pachymetry Evaluation**

The same SST (Orbscan-II, version 3.12; Bausch & Lomb, Rochester, NY) and NCSM (Topcon SP-3000P, version 1.31; Topcon Corp., Tokyo, Japan) devices used throughout the whole study were always kept calibrated. Pachymetry measurements were obtained 6 months after myopic ASA surgery. For acquiring SST data, the patient was instructed to fixate on a flickering red light. Before proceeding, the patient blinked to obtain a homogeneous tear film layer. The instrument was then aligned and the cornea was scanned by a slit-beam. The built-in statistical analysis software of the SST device calculated the elevation data of the anterior and posterior corneal surfaces; thus, pachymetry is the result of subtracting the elevation map of both corneal surfaces.19,20 The SST instrument displays pachymetry values at any corneal location scanned; however, only the central thickness was analyzed. The default acoustic equivalent setting used was 0.92.21 Examinations were performed during a specific period (11 AM-1 PM) to minimize the possible effect of diurnal variations in corneal thickness.22

For NSCM CCT gauging the patients were positioned with their chins in a cup and a forehead against a headband. The CCT was measured while the subject focused on a fixation light in the instrument. After proper positioning of the alignment dot, square, and bar on the screen, the pachymetry was automatically obtained. NCSM was performed immediately before or after SST depending on the order determined by a computer-generated random table. The order of the pachymetry measurements performed using both techniques (SST and NCSM) was always randomized to prevent bias. In addition, the order of the measurements performed by each examiner was also randomized. All measurements were performed within the shortest time to prevent any effect of fatigue bias. When pachymetry measurements were successively obtained (i.e., intra-observer repeatability measurements) patients kept their heads as steady as possible without sitting back for both noncontact techniques.

**Statistical Analyses**

**Intraobserver Repeatability.** To investigate the intraobserver repeatability of SST and NCSM for CCT, the first examiner obtained independent test results using the same method on the same subject and the same equipment with the shortest time possible between successive sets of readings. This first examiner performed five consecutive examinations in 63 eyes after ensuring proper focusing and alignment. To calculate the intrasession repeatability, the within-subject standard deviation (Sw) of the five consecutive measurements was calculated by obtaining the square root of the value, referred to as the residual mean square, in one-way analysis of variance.16 The precision was defined as the difference between a subject’s measurement and the true value (average value that would be obtained over many measurements) for 95% of observations and was defined as ±1.96 × Sw.16 Repeatability, or the value below which the difference between two measurements would lie with a probability of 0.95, was also analyzed and was defined as 2.77 × Sw.16 We also calculated the intrasession correlation coefficient of variation (CVw).16 The intrasession reliability of the measurement method also was calculated with the intraclass correlation coefficient (ICC).16

**Interobserver Reproducibility.** To calculate interobserver reproducibility of SST and NCSM for CCT, a second examiner obtained only one SST and NCSM CCT measurement. The first of the five CCT measurements performed by the first examiner with each technique was computed to establish agreement between observers. The paired t-test was used to establish whether there was a significant systematic bias between observers. The 95% limits of agreement (LoA) were defined as the mean difference in measurements performed by two different examiners ±1.96 × SD of the differences.16 The interobserver Sw, precision, reproducibility, CVw, and ICC were also calculated.16

**Agreement between Techniques.** The paired t-test was used to establish whether there was a significant systematic bias between SST and NCSM techniques. Graphs of the differences from the means were plotted to ascertain that there was no relation between the differences and the range of measurement and that the differences between measurements were approximately normally distributed.17 The first of the five CCT measurements made by the first examiner using SST and NCSM was computed to calculate agreement between both techniques.

**Intersession Reproducibility.** To evaluate intersession reproducibility, a second session was scheduled 1 week after the first one. The first of the five CCT measurements obtained by the first examiner during the first session was computed to establish reproducibility between sessions. Measurements obtained during the second session were always performed by the first examiner. Only one pachymetry measure was acquired. The 95% LoA, the intersession Sw, precision, reproducibility, CVw, and ICC were calculated.16 The paired t-test was used to establish whether there was a significant systematic bias between sessions.

**Basic Statistical Procedures.** Data from the prospectively completed forms were entered into a database, and statistical calculations were performed using SPSS version 18.0 for Windows (SPSS, Cary, NC). Data distribution was evaluated using the Shapiro- Wilk test and normality was found to hold for all analyses. The mean and SD were calculated for normally distributed data. Spearman’s rank
correlation coefficient ($r_c$) was used to measure the association between the mean of pachymetry readings and the absolute value of the difference between two readings, or the SD of five readings, prior to proceed with repeatability, reproducibility, or agreement analyses. When a significant relationship was found, the $S_w$ or the LoA of the crude data were not provided because they are not appropriate methods to represent measurement error under those circumstances. Then again, when conventional Bland-Altman graphs showed an association between the signed difference and average CCT values (tendency), a better fit than the above-mentioned crude LoA was obtained by using a regression model described by Bland and Altman. For all statistical tests, a two-tailed $P < 0.05$ was considered significant.

We underwent a preliminary analysis with the first 10 subjects as a pilot study to obtain the standard deviations of the data distribution and calculate sample size. Sample size was estimated by a power analysis for difference between means, setting the significance level and statistical power at 5% and 80%, respectively. For the intraobserver repeatability, interobserver reproducibility and agreement studies, we set a minimal detectable difference of 25 $\mu m$ based on our previous study in LASIK patients and a somewhat wider variation expected from surface ablation techniques compared to LASIK. The SST provided a larger standard deviation ($50.4$ $\mu m$) than NCSM that yielded a required sample size of 65 subjects. For the intersession reproducibility study, we set a minimal detectable difference of 35 $\mu m$ based also on our previous study in LASIK patients and a somewhat wider variation expected from surface ablation techniques compared to LASIK. The SST provided a larger standard deviation ($43.1$ $\mu m$) than NCSM that yielded a required sample size of 24 subjects.

## RESULTS

The intrasession repeatability, interobserver reproducibility, and the agreement between techniques were studied in 65 eyes of 65 patients (26 men, 37 women). The average patient age was 32.2 $\pm$ 6.1 (SD) years (range, 21–45 years). The mean postoperative sphere was $-0.12 \pm 0.29$ dioptries (D) (range, $+0.50$ to $-0.50$ D) and the median astigmatism was $-0.25$ D (interquartile range [IQR]: 0 to $-0.50$ D). Pachymetry measurements were obtained 184.03 $\pm$ 7.23 days after the ASA surgery.

### Intrasession Repeatability

Table 1 shows the overall average CCT values corresponding to the repeated measures, the intrasession $S_w$, the precision, the repeatability, the $CV_w$, and the ICC. Intrasession reliability of both techniques was good.

### Interobserver Reproducibility

Table 2 shows the overall average CCT values, the interobserver $S_w$, the precision ($2.77 \times S_w$), the $CV_w$, and the ICC corresponding to the interobserver analysis. The mean differences between observers were $-0.46$ (95% confidence interval [CI], $-2.93/2.01$) $\pm$ 9.82 $\mu m$ for SST and 1.01 (95% CI, $-0.33$ to 2.36) $\pm$ 5.36 $\mu m$ for NCSM. There was no statistically significant difference between the set of measurements obtained by each examiner neither for SST ($P = 0.71$) nor for NCSM ($P = 0.14$).

### Agreement between Techniques

SST provided higher readings than NCSM; mean difference between systems was 13.39 (95% CI: 8.49–18.29) $\pm 19.46$ $\mu m$ ($P < 0.0001$). A Bland–Altman plot created to assess the difference in individual measurement as a function of the mean of two measurements (Fig. 2) revealed poor agreement because the crude LoA were wide (76.28 $\mu m$; range: $-24.75$–51.53 $\mu m$) and there was an association between the average of both measurements and the difference between SST and NCSM CCT readings (Fig. 2). Therefore, there was a trend in the bias, a tendency for the difference to increase with increasing CCT magnitude ($r_c = 0.45$, $P = 0.001$). Thus, the regression-based 95% LoA model was fitted. Mean difference ($SST - NCSM$) could be calculated with the following formula (Formula A): $-66.46 + 0.17 \times$ Average CCT. Similarly to what happened in case of SST for interobserver reproducibility, the differences between the observed difference and the difference predicted by this regression model were again used to model the relationship between the SD of the differences and the magnitude of the pachymetry. In this case, $SST - NCSM$ could be fitted with the following equation: $y = -0.80 + 0.26 \times$ Average CCT; lower limit = $-80.31 + 0.26 \times$ Average CCT; upper limit = $-52.60 + 0.08 \times$ Average CCT, which are also shown in Figure 2.

### Interobserver Reproducibility

Intersession reproducibility was studied in 24 eyes of 24 patients (6 men, 18 women). The average patient age was 33.08 $\pm$ 5.1 years (range, 28–42 years). The mean postoperative sphere was $-0.09 \pm 0.31$ D (range, $+0.50$ to $-0.50$ D) and the median astigmatism was $-0.25$ D (IQR: 0 to $-0.50$ D). Pachymetry

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**Table 1.** SST and NCSM Intrasession Repeatability Values after Myopic ASA

<table>
<thead>
<tr>
<th>Technique</th>
<th>Overall Mean $\pm$ SD (Range), $\mu m$</th>
<th>$S_w$ (95% CI)</th>
<th>Precision ($1.96 \times S_w$)</th>
<th>Repeatability ($2.77 \times S_w$)</th>
<th>$CV_w$ (%) (95% CI)</th>
<th>ICC (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST</td>
<td>468.04 $\pm$ 47.82 (386–583)</td>
<td>7.35 (6.71–7.99)</td>
<td>14.40 (13.15–15.66)</td>
<td>20.36 (18.58–22.13)</td>
<td>1.57 (1.43–1.70)</td>
<td>0.97 (0.96–0.99)</td>
</tr>
<tr>
<td>NCSM</td>
<td>455.14 $\pm$ 41.32 (578–572)</td>
<td>3.81 (3.48–4.14)</td>
<td>7.46 (6.82–8.11)</td>
<td>10.55 (9.63–11.46)</td>
<td>0.83 (0.76–0.90)</td>
<td>0.99 (0.98–0.99)</td>
</tr>
</tbody>
</table>
measurements during the second session were obtained 7.04 ± 0.7 days after the first session. Table 3 shows the overall average CCT values corresponding to the two examinations, the intra-session S_w, the precision, the reproducibility, the CV_w, and the ICC corresponding to the intersession analysis.

The mean differences between sessions were −0.91 (95% CI, −8.36–6.53) ± 17.63 μm for SST and −2.00 (95% CI, −7.03–3.03) ± 11.92 μm for NCSM. There was no statistical difference between the set of measurements obtained by each examiner neither for SST (P = 0.41) nor for NCSM (P = 0.80). Figure 3 shows the Bland–Altman plots of difference versus mean for SST and NCSM. The scatterplot showed that the difference in CCT values was independent of the mean CCT value. Table 4 shows the 95% LoA corresponding to the intersession variability for both techniques; the NCSM LoA width was narrower than the SST one.

**DISCUSSION**

Refractive corneal surgery following ASA techniques has gained increasing popularity due to its reduced impact on corneal biomechanics compared to LASIK. The reliability (random error) of pachymetry measurements obtained by any ophthalmic instrument should always be clinically determined to avoid misdiagnosis based on the readings when providing counseling for corneal laser enhancements, glaucoma diagnosis and treatment, and pseudophakic intraocular lens power calculations. Therefore, it is mandatory to determine the reliability of noncontact pachymetry methods after myopic ASA that are widely used in the clinical setting (like SST and NCSM), to conclude if they are repeatable and reproducible, beyond eliminating the risk of corneal epithelial damage and microbial contamination associated with US probe contact.

Intrasession repeatability values using both SST and NCSM pachymetry techniques for gauging CCT were clinically good.
NCSM obtained an intrasession repeatability value that was nearly two times better than the SST one (Table 1). Our research group has previously reported SST and NCSM intrasession repeatability outcomes after LASIK and we found similar variability intrasession repeatability values (20.2 and 12.8 μm for SST and NCSM, respectively)\(^{15}\); thus, we suggest that there might not be a clinical difference in SST and NCSM random error when gauging CCT between myopic LASIK and ASA patients having no clinically significant corneal haze. This absence of clinical difference regarding CCT measurement repeatability was also reported by Savini et al.\(^ {25}\) using a dual Scheimpflug analyzer (Galilei; Zeimer Group, Port, Switzerland).

We found an inverse relationship between the variability (absolute value of the difference) and the CCT magnitude for SST interobserver reproducibility data; thus, our SST interobserver variability outcomes (Table 2) should be interpreted according to the CCT magnitude: more unreliable estimates between observers should be expected in thinner corneas. Although systematic differences between observers were negligible (0.46 μm), the Bland-Altman graph showed a tendency for the SST CCT mean difference to decrease with increasing CCT magnitude (Fig. 1A). In contrast, NCSM Bland-Altman analysis (Fig. 1B) showed good agreement between observers regardless of the CCT magnitude, narrower crude LoA, and insignificant systematic error (1.01 μm) between observers, which suggests its clinical appropriateness for assessing central pachymetry after the intermediate postoperative period. Spadea et al.\(^ {26}\) also performed Bland-Altman interobserver analysis in 1-month post-ASA patients using optical low coherence reflectometry (OLCR) and US techniques; they reported narrower interobserver LoA width values (13.9 and 9.3 μm, respectively) compared to ours (SST = 38.49 μm, NCSM = 21.01 μm). Nonetheless, it must be taken into account that the OLCR device provides one single CCT value after averaging 16 measurements, and for the US technique, they computed the average of three consecutive CCT measurements; we only obtained one CCT reading for each noncontact technique.

Regarding the agreement between SST and NCSM after myopic ASA, we found a SST systematic overestimation of 13.39 μm and a significant association between the average of CCT measurements and the difference between techniques as well as wide crude LoA after applying Bland-Altman analysis (Fig. 2). Therefore, we can state that both techniques are not directly interchangeable after myopic ASA, nor after myopic LASIK as was previously reported.\(^ {15}\) However, we provided adequate regression-based formulas for those clinicians that desire to know the actual relationship between both techniques when gauging CCT after myopic ASA. Jonuscheit and Doughty\(^ {21}\) reported similar systematic differences (14 μm) between these techniques in healthy corneas; they also found similar upward trend with increasing CCT magnitude (Fig. 2) when they evaluated the agreement between SST and NCSM.

### Table 3. SST and NCSM Intrasession Reproducibility Values after Myopic ASA

<table>
<thead>
<tr>
<th>Technique</th>
<th>Overall Mean ± SD (Range), μm</th>
<th>S(_w) (95% CI)</th>
<th>Precision (1.96 × S(_w))</th>
<th>Reproducibility (2.77 × S(_w))</th>
<th>CV(_w) (%) (95% CI)</th>
<th>ICC (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST</td>
<td>460.29 ± 47.63 (393–544)</td>
<td>12.22 (8.76–15.68)</td>
<td>23.95 (17.16–30.73)</td>
<td>35.84 (24.26–43.43)</td>
<td>2.65 (1.90–3.40)</td>
<td>0.94 (0.85–0.97)</td>
</tr>
<tr>
<td>NCSM</td>
<td>445.75 ± 40.65 (382–521)</td>
<td>8.37 (6.00–10.74)</td>
<td>16.40 (11.76–21.05)</td>
<td>23.18 (16.62–29.74)</td>
<td>1.87 (1.34–2.41)</td>
<td>0.95 (0.90–0.97)</td>
</tr>
</tbody>
</table>

### Table 4. Intersession Reproducibility 95% LoA for SST and NCSM after Myopic ASA

<table>
<thead>
<tr>
<th></th>
<th>SST, μm</th>
<th>NCSM, μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper LoA (95% CI)</td>
<td>33.59 (20.69–46.49) m</td>
<td>21.37 (12.64–30.01)</td>
</tr>
<tr>
<td>Lower LoA (95% CI)</td>
<td>–35.46 (–48.36 to –22.56)</td>
<td>–25.37 (–34.09 to –16.64)</td>
</tr>
<tr>
<td>LoA width</td>
<td>69.05</td>
<td>46.74</td>
</tr>
</tbody>
</table>
The upward or downward trend in the bias typically found when assessing CCT measurement agreement following Bland-Altman analysis between SST and other techniques (US, Scheimpflug, and NCSM) is obtained as a result of the peculiar SST measurement procedure, and this fact has been reported regardless of assessing either normal or post-LASIK/ASA surgery.\(^{13,15,27,28}\) It seems that SST tends to underestimate thin corneas and slightly overestimate thicker ones when compared with the gold standard US technique,\(^{13,27,28}\) although US might overestimate actual CCT because of the corneal swelling due to the effect of corneal anesthetics.\(^{29}\) Previous authors have stated that SST measures thinner when there is loss of corneal transparency,\(^{8,14,30}\) and that underestimation is directly correlated with the grade of haze.\(^{8}\) Therefore, this hypothesis could be applied to previous outcomes reported after corneal laser surgery in both LASIK and ASA patients,\(^{13,27,28}\) because nonclinically significant haze could be overlooked during follow-up biomicroscopy examination. However, the SST under- and overestimation compared to US depending on CCT magnitude illustrated by previous authors\(^{13,27,30-31}\) in healthy corneas without prior surgery is not explained by this hypothesis. Therefore, SST has an additional inherent CCT measurement limitation that might be associated with its corneal analysis procedure, which is not fully compensated for by applying an adequate instrument calibration through the setting of an acoustic factor.\(^3\) Therefore, we hypothesize as Chakrabarti et al.\(^{33}\) did that the SST system might rely on reconstructing algorithms primarily based on prolate-shaped corneas, which might not work properly when assessing spherical and oblate-shaped corneas, despite being apparently transparent. Hence, this is also an inherent SST CCT measurement shortcoming that might be further enhanced in the case of post-laser markedly oblate-shaped corneas as showed previously through Bland-Altman analysis.\(^{13,27,28}\)

We could not find significant differences between sets of CCT measurements performed 1 week apart using both SST and NCSM techniques. Nonetheless, intersession reproducibility outcomes (Table 5) were poorer than those obtained for intrasession analysis. One of the reasons for obtaining poorer variability results is a result of not gauging the pachymetry to correspond to the same corneal location measured during the first session. Using solely a chin rest and a forehead do not guarantee that the pachymetry occurs at the same corneal point as the first session unless an anatomical recognition system is used, as some wavefront sensors have already incorporated.\(^34\) The way the patient places the head is quite likely to be different, a shortcoming that affects both techniques. The performance of NCSM was again better than SST; however, both techniques obtained excellent ICC values (>0.97). The intersession CV\(_w\) for SST can still be considered clinically acceptable (2.6%) and was similar to the one previously reported for SST after LASIK (2.45%),\(^{15}\) which indicates that SST has similar CCT measurement reliability for both myopic LASIK and ASA patients when there is no clinically significant corneal haze. Nonetheless, the width of the LoA for SST in our study (69.05 μm) was much higher than the previously reported value for normal corneas (26 μm).\(^{35}\)

The current study had several limitations. This study included only post–myopic ASA patients, thus, the conclusions cannot be applied to patients who have undergone hyperopic-ASA surgery, whose postoperative corneal shape is even more prolate than normal corneas. Both examiners who participated in the present study had expertise in the use of both pachymetry methods; thus, interobserver variability results should be expected to be poorer for nonexperienced users, especially for SST. Finally, we evaluated the random error when measuring post–myopic ASA CCT with two noncontact methods under repeatability and reproducibility conditions, rather than their accuracy. US CCT gauging was not performed in the study eyes, thus, precluding direct comparison of both SST and NCSM with the contact gold standard method; however, such a comparison has already been reported extensively after corneal laser surgery.\(^{13,27-30,36}\)

In conclusion, given that CCT measurements obtained by any ophthalmic instrument should be always checked for reliability analysis prior to its clinical use to avoid misleading diagnosis or treatment based on flawed CCT readings, the present study provided scientific estimates of the intrasession repeatability and the interobserver and intersession reproducibility of CCT measurements in myopic ASA patients in their intermediate follow-up. This study showed first that SST and NCSM provide dependable CCT measurements during intra-session assessment, especially the latter noncontact pachymetry technique; second, that CCT measurement consistency of these techniques is similar from a clinical standpoint to that reported in post–myopic LASIK reliability studies,\(^{15}\) and third, that SST and NCSM CCT are not interchangeable because differences between techniques highly depend on CCT magnitude and that NCSM provides superior interobserver reproducibility than SST across different CCT values. Additionally, we provided the threshold for a significant change in CCT, which would be the repeatability and/or reproducibility (2.77 \(\times \) \(S_d\)) value herein determined. The precision of SST and NCSM after myopic ASA is adequate in patients having no clinically significant corneal haze and might be a reliable alternative to contact central pachymetry.

References


