**Regional Changes in Posterior Corneal Surface During a 6-Month Follow-up Period after tPRK, FS-LASIK and SMILE**

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**Conflict of Interest**

The authors indicate no financial conflict of interest.

**Running title**

Regional changes in corneal shape post refractive surgeries

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**Highlights**

While different refractive surgery procedures produce different posterior surface changes in the cornea, these changes appear to be dependent on the ablated and residual stromal thickness in the paracentral region.

**Abstract:**

**Purpose:** To investigate changes in corneal curvature in different zones of the posterior corneal surface during a 6-month follow-up period after tPRK, FS-LASIK and SMILE.

**Methods:** The study included a total of 202 eyes, including 65, 77, and 60 that underwent tPRK, FS-LASIK, and SMILE, respectively. Elevation data for the posterior surface were obtained pre-operatively (pre), as well as 1 week (pos1w), 1 month (pos1m), 3 months (pos3m), and 6 months (pos6m) postoperatively. Changes in posterior corneal curvature (M) were analyzed in the central (diameter 0–3 mm), paracentral (diameter 3–6 mm), and peripheral regions (diameter 6–9 mm).

**Results:** Over all follow-up periods, the central region of the posterior surface in all patients became flatter (P < 0.05) with FS-LASIK showing the largest change, while the paracentral and peripheral regions became steeper. The posterior curvature changes between pre and pos6m, determined before and after correction for ablated stromal depth (ASD), tended to follow similar trends in the 3 regions and after the three surgeries. There was also no significant correlation (P > 0.05) between the changes in the mean curvature (M, recorded between pre and pos6m) and each of the refractive error correction, the changes in spherical aberration postoperatively, the optical zone diameter, ASD and residual stromal bed thickness in the central and peripheral regions, but the correlation was significant in the paracentral region.

**Conclusions:** The postoperative changes in posterior corneal shape followed different trends in the central, paracentral and peripheral regions. The FS-LASIK group exhibited the most notable changes in posterior corneal curvature, especially in the central region, and these changes were statistically correlated with variations in spherical aberration, and ablated and residential stromal thickness in the paracentral region.

**Keywords:** curvature, different zones, posterior corneal surface, tPRK, FS-LASIK, SMILE

**Introduction**

Laser vision correction (LVC) surgeries are becoming increasingly popular with two main forms: surface keratectomy as in transepithelial photorefractive keratectomy (tPRK), and lamellar keratectomy, represented by femtosecond laser-assisted excimer laser in situ keratomileusis (FS-LASIK) and small incision stromal lens extraction (SMILE). tPRK has a relatively low ablation depth, and avoids tissue separation (with no flap or cap)1. On the other hand, FS-LASIK and SMILE are relatively similar in safety, effectiveness and predictability 2,3, but SMILE maintains better anterior stromal continuity 3,4.

There is currently growing interest in exploring the changes in corneal shape that occur after refractive surgery while considering the ablation depth and the changes in corneal and epithelial thickness 5-9. Most studies regarded the cornea as a single entity and analyzed corneal changes during refractive surgery in terms of average characteristics. However, the significant regional variations in corneal microstructure – including differences in collagen fibril anisotropy, interweaving and density, leading to variations in in-plane, flexural and shear stiffness – would be expected to lead to different regional changes in corneal shape post-surgery 10,11.

Since LVC surgeries are only intended to affect the anterior corneal surface, any associated changes in posterior shape are considered unintended consequences 12,13. The present study considers this point, and prospectively analyzes corneal tomography data of patients with myopia and astigmatism before and after tPRK, FS-LASIK and SMILE. It examines the central, paracentral and peripheral regions of the posterior surface, and explores the effects of the three surgeries at different timepoints using an analysis method developed in a previous study and described below 14.

**Patients and Methods**

***Participants***

A total of 202 patients (81 males and 121 females) of Chinese ethnicity underwent tPRK (n = 65), FS-LASIK (n = 77), or SMILE (n = 60) and completed 6 months of follow up at the Eye Hospital of Wenzhou Medical University. Informed consent was obtained from all participants to use their data in research. All LVCs were performed by the same surgeon (YFY). The study was reviewed and approved by the Ethics Committee of the Hospital.

The patients were evaluated preoperatively (pre) and followed up postoperatively at 1 week (pos1w), 1 month (pos1m), 3 months (pos3m), and 6 months (pos6m). Patient inclusion criteria were: a spherical error between -1.00 and -10.00 diopters (D); astigmatism not exceeding -3.00 D; stable refraction over the preceding year; and discontinuation of contact lens wear for 2 weeks prior to surgery. Patient exclusion criteria were: a history of ocular surgeries or trauma; corneal opacity or scarring; clinically suspected or confirmed keratoconus; abnormal corneal tomography; pregnancy or breastfeeding. All patients underwent a complete preoperative examination (including corneal tomography) before surgical refractive correction.

***Surgical Techniques***

In the tPRK group, ablation of corneal epithelium and stroma was performed in a single step under the aberration-free mode of the AMARIS 1050 Hz excimer laser (SCHWIND eye-tech-solutions, Kleinostheim, Germany). In the FS-LASIK group, lamellar flaps with a superior hinge, thickness of 95–110 µm, and diameter of 8.5–9.0 mm were formed with a femtosecond laser (Ziemer Ophthalmic Systems AG, Port, Switzerland); FS-LASIK ablation was then applied using the AMARIS laser. In the SMILE group, the procedure was carried out using a VisuMax femtosecond laser (Carl Zeiss Meditec, Jena, Germany); a stromal lenticule was removed and a cap ranging in thickness from 115 to 140 µm was left.

The three procedures shared similar postoperative care. After the surgery, one drop of tobramycin/dexamethasone (Tobradex; Alcon, TX, USA) was instilled at the surgical site. Then, a bandage contact lens (Acuvue Oasys; Johnson & Johnson, FL, USA) was placed on the cornea for one day in the FS-LASIK group and for 5-7 days in tPRK until complete corneal re-epithelization. Other postoperative regimens in the three groups included fluorometholone 0.1% (Flumetholon; Santen, Osaka, Japan) and topical levofloxacin 0.5% (Cravit; Santen, Osaka, Japan). In all three groups, a postoperative tapering dose of fluorometholone was given 4 times per day, with a tapering period of one month for the FS-LASIK and SMILE groups, and 2–3 months for the tPRK group.

***Data Acquisition***

Surgical parameters including refractive error correction (REC), optical zone diameter (OZD), ablation zone diameter (AZD), cap diameter (CAPD), and ablated stromal depth (ASD) were recorded from surgery planning and treatment printouts. REC was converted into a corrected mean spherical equivalent (SE). For tPRK, ASD was recorded as the ablation depth minus the central ablated epithelium thickness. Original elevation data measured with a Pentacam (OCULUS Optikgerate GmbH, Wetzlar, Germany, software version: 6.02r23 – not the relative elevation data calculated based on the best fit sphere or other reference surfaces shown in the GUI of Pentacam software) were exported in the form of a Cartesian grid 15. The exported elevation data, centered on the posterior corneal vertex, which had the minimum elevation value, was transformed into polar coordinates using the approach described in our previous studies 14,16. Spherical aberration (SphAb) was also measured in each stage with the Pentacam. At least three posterior surface measurements with quality factor ≥ 90% were taken at each timepoint, and the measurement with the best quality factor was selected for analysis.

This was followed by intraocular pressure (IOP) examination using a PASCAL Dynamic Contour Tonometer (DCT) (SMT Swiss Microtechnology AG, Port, Switzerland). DCT-IOP measurements were carried out twice with at least 5 minutes in between, preceded by topical anesthesia using proxymetacaine 0.5% (Alcaine; Alcon, Missisauga, Canada). All examinations were taken with the patient in a sitting position by a single experienced examiner (WH) during a single clinic visit, within the same half-day session (morning [08:30–11:30] or afternoon [13:30–16:30]) to minimize diurnal effects 17. The participants who did not complete the 6 months postoperative follow-up were excluded from the study. Since bilateral eyes are not independent of one another 18 and may have mirror symmetry 16, only the right eye of each participant was included.

***Analysis of Posterior Corneal Curvature***

Due to the reduced reliability of peripheral data and possible interference of eyelids and eyelashes, only elevation data within the middle 9 mm-diameter zone were used in analysis 19. The posterior surface elevation data were fitted to a Zernike expression of the 10th order as in our previous study 14, and the mean equivalent corneal curvature (M) was then calculated by a vector decomposition formula described in an earlier study 20 in the central region (diameter: 0–3 mm), the paracentral region (3–6 mm), and the peripheral region (6–9 mm). A change in posterior curvature was calculated as the postoperative minus the preoperative value; therefore, if the curvature became steeper, the change would be negative.

***Statistical Analysis***

All data were analyzed using SPSS 20.0 statistical software (IBM，SPSS Statistics, version 20). M and its changes at different follow-up points were tested using the MANOVA of repeated measurements. One-way ANOVA and ANCOVA (Analysis of Covariates) with a general linear model were used to compare the changes in M between pre and pos6m in different corneal regions among the three surgery groups, where ASD was considered a covariate. Pearson or Spearman correlation analysis was used to evaluate the correlation between curvature of the posterior corneal surface, operation parameters (REC, OZD, ASD, RSB), and the change in SphAb for normally and non-normally distributed data, respectively. P< 0.05 was considered indicative of statistical significance.

**Results**

***Baseline characteristics***

The three groups (tPRK, FS-LASIK, and SMILE) were matched in age, central corneal thickness (CCT), spherical manifest REC (SREC), cylindrical manifest REC (CREC), OZD, SphAb and DCT-IOP (Table 1). ASD in SMILE group was larger than in both tPRK (P < 0.01) and FS-LASIK (P < 0.01), while it was not significantly different (P = 0.162) in tPRK and FS-LASIK. AZD in the tPRK group was larger than in both FS-LASIK (P < 0.01) and SMILE (P < 0.01), but it was not significantly different (P = 0.341) in FS-LASIK and SMILE. On the other hand, RSB was significantly different when comparing values within each pair of LVC procedures (all P < 0.01).

***Changes in spherical aberration***

SphAb increased after surgery (pre vs pos1m, all P < 0.01 for the three groups) and remained almost unchanged in both the FS-LASIK and SMILE groups over the follow-up period, while there was a slight fluctuation in the tPRK group. The change in SphAb between pos6m and pre (SphAb-dif) was smallest in SMILE (0.129±0.121 μm) with significant differences vs FS-LASIK (P = 0.008), intermediate in tPRK (0.202±0.240 μm, P = 1.000 vs FS-LASIK), and largest in the FS-LASIK group (0.222±0.152 μm). After correction for ASD, SphAb-dif followed similar trends (FS-LASIK > tPRK ≈ SMILE, P < 0.01).

***Changes in spherical corneal curvature***

Within the 0-3-mm diameter central region, the posterior cornea became flatter after surgery (pre vs pos1m, all P < 0.01 for the three groups) and remained almost unchanged in both the FS-LASIK and SMILE groups over the follow-up period, while there was a slight fluctuation in the tPRK group (Figure 1A). The central flattening at pos6m (vs pre) was smallest in tPRK (0.010±0.034 D) with significant differences vs FS-LASIK (P = 0.003), intermediate in SMILE (0.015±0.039 D, P = 0.031 vs FS-LASIK), and largest in the FS-LASIK group (0.032±0.040 D) (Table 2). After correction for ASD, the central curvature followed similar trends (FS-LASIK > SMILE ≈ tPRK, P = 0.002). Furthermore, there was no correlation between REC (total: r = -0.094, P = 0.181), OZD (total: r = -0.069, P = 0.330), ASD (total: r = 0.086, P = 0.222), RSB (total: r = -0.036, P = 0.609) or SphAb-dif (total: r = 0.010, P = 0.886), with the changes in M at pos6m compared to preoperative measurements.

In contrast, the posterior peripheral annulus region (6-9-mm diameter) showed the opposite trend; curvature became steeper after surgery (pre vs pos1m, all P < 0.05 for the three groups), then remained almost unchanged throughout the follow-up period in the SMILE group, while it fluctuated in the tPRK and FS-LASIK groups (Figure 1C). The steepening at pos6m compared with pre-surgery was most pronounced in the tPRK group (-0.055±0.083 D), followed by SMILE (-0.044±0.114 D) and FS-LASIK groups (-0.029±0.084 D) (Table 2). However, these changes were not statistically significant in all three LVC groups (P = 0.264). After correction for ASD, the changes in peripheral posterior curvature post-surgery (pos6m – pre) were not significant in all three LVC groups (P = 0.257). There was also no correlation between the changes in M at pos6m with REC (total: r = -0.004, P = 0.952), OZD (total: r = -0.023, P = 0.750), ASD (total: r = -0.029, P = 0.685), RSB (total: r = 0.007, P = 0.918) or SphAb-dif (total: r = -0.031, P = 0.663).

Posterior surface shape changes within the paracentral annulus region (with diameter between 3 and 6 mm) were similar to those recorded in the peripheral region (Figure 1B). The steepening at pos6m compared with pre was -0.014±0.035 D (P = 0.002), -0.028±0.046 D (P = 0.000), and -0.029±0.045 D (p < 0.001) in the tPRK, FS-LASIK, and SMILE groups, respectively (Table 2). However, the post-pre changes in paracentral posterior curvature were not significantly different among the three LVCs (P = 0.067), and this observation remained valid after correction for ASD (P = 0.182). Further, these curvature changes were correlated with REC (total: r = 0.229, P = 0.001), OZD (total: r = 0.174, P = 0.014), ASD (total: r = -0.196, P = 0.005), RSB (total: r = 0.155, P = 0.027) and SphAb-dif (total: r = -0.174, P = 0.013).

**Discussion**

It is important to recognize changes in the posterior corneal surface after refractive surgery as these changes may be indicators of serious complications such as postoperative corneal ectasia 21. The measurement of posterior corneal surface changes should be performed with accurate and reliable devices to allow early detection of postoperative corneal ectasia. In this study, we evaluated changes to the posterior surface during a 6-month follow-up period after three types of LVC (tPRK, FS-LASIK, and SMILE) using a Scheimpflug tomography system which has been reported to be highly reliable 19,22. We demonstrated that, after these LVCs, corneal curvature in the central posterior surface decreased (leading to flattening), while corneal curvature increased (showing steepening) in the paracentral and peripheral regions. These changes were correlated to the changes in spherical aberration after LVC, and dependent on the ablated and residual stromal thickness in the paracentral region. Although the changes in curvature were slight, most differences did achieve statistical significance. In addition, the changes were maintained throughout the follow-up period.

While the unintended changes in posterior corneal shape that occur after refractive surgery have been the subject of several studies, no agreement has been reached as yet. Some studies reported no change in posterior surface elevation 23 and curvature 24-26, others presented increases in elevation 27-31 or posterior curvature 32, including slight central flattening and peripheral steepening 9,14 (in agreement with the present study), followed by longer-term flattening 12,32-35 or small fluctuations 5,36. Possible reasons behind these differences in results include the use of different tomography measurement technologies. Unlike the Pentacam, Orbscan was reported to overestimate posterior corneal elevation due to noise in the measurement data and inaccuracies in system alignment for measurements after surgeries 37 38. Secondly, the shape change in anterior corneal surface induces alterations in corneal refractive index, magnification ratio of the posterior surface and transparency in the early postoperative period which, when combined with the misidentification of stromal interface and stromal haze 39 40 41,42,can influencethe tracing of posterior corneal surface as described in our previous study 43.

The present study has the following advantages over previous work. Firstly, prior studies used posterior elevation data (or height data) 13,28, the reference plane of which coincided with the apex of the posterior surface and was, therefore, affected by the shift that took place due to the refractive surgery procedure 14. In contrast, this study used posterior curvature data, which relied instead on the relative positions of adjacent points and was independent of the reference plane. Secondly, in previous studies 13,28, changes in the posterior surface were rarely considered in different zones, and the analysis focused instead on the whole surface and its average changes. The approach adopted in our study was thought to be necessary as both the corneal microstructure and the changes that take place in it due to surgery vary significantly across corneal surface, possibly leading to corresponding regional variations in corneal geometry.

When the central corneal lamina was eliminated due to surgical ablation, the surrounding tissue in the corneal periphery lost its biomechanical balance and became relaxed, shorter and thicker 44, then changed the spherical aberration. The microstructural change in the paracentral and peripheral cornea then led to an outward radial force that flattened the central cornea, which was confirmed by the fact that these effects in paracentral area were correlated with optical zone diameter, refractive error correction and residual stromal bed. In agreement, a study that analyzed clinical data on tomography changes following tPRK found that while the peripheral region experienced significant forward shifts, the central region moved backwards 45. The changes in corneal geometry caused by refractive surgery are therefore not simply the result of subtraction of ablated tissue but also the change in distribution of mechanical stiffness and the need to find a new equilibrium state. In the present study, that effect led to steeper curvature of the posterior peripheral region in all three cornea groups, remaining evident 6 months after surgery.

During the 6-month follow-up period, the largest change in M (post – pre-operation) in the central posterior surface was in the FS-LASIK group, indicating that the stretch of the central region was largest in that group, then induced the highest change in spherical aberration. FS-LASIK surgery exerts a large impact on corneal biomechanics due to the existence of the corneal flap 36,46. Dawson et al found that Bowman’s layer is the strongest part of the cornea, followed by the anterior of the central stroma (about 40% depth) 47. Compared with FS-LASIK, SMILE involves only a micro-incision in the Bowman’s layer and maintains a relatively intact anterior stroma 48. On the other hand, the effect of tPRK, a surface ablation procedure, on corneal biomechanics is less than that of both FS-LASIK and SMILE as the percentage of tissue altered in the central cornea is smaller for the same degree of refractive correction 49.

The differences in effect of tPRK and SMILE appear to be, at least in part, due to differences in corneal healing. Studies have shown that the corneal epithelium was still irregular one week after tPRK, with keratinization visible in some zones 50. In contrast, on the first day after SMILE, the corneal epithelium is smooth, collagen fibers in the stroma arranged regularly, and endothelial cells closely arranged with consistent thickness 50. These differences in the process of corneal healing are reflected in the fluctuations observed in the changes (pre- versus post-surgery) in the posterior surface; the degree of change is relatively stable within the SMILE group when compared with the FS-LASIK and tPRK groups.

In the statistical analysis, the three surgery groups were matched in OZD with no significant differences between the groups (tPRK group: 6.55±0.37 mm; FS-LASIK group: 6.61±0.32 mm; SMILE group: 6.59±0.20 mm, p = 0.533). When the same cutting diameter range was used, a larger amount of tissue was removed during SMILE than in the other LVCs and so the curvature of the SMILE group was steepest in the paracentral region. Meanwhile, the changes in spherical aberration postoperatively were lowest in SMILE group, which was similar to our previous study.

In this study, while the changes in posterior curvature following the three procedures were significantly different, these differences may be too small to be considered clinically relevant. The different laser ablation instruments used in different LVCs vary in their cutting algorithms, and this may cause small changes in post-surgery tomography 14. Epithelial remodeling may also play a role in post-surgery changes in corneal shape, but this role remains controversial 51. Further, while epithelial response to myopic ablation was greater in the central region than in the pericentral region in some studies, others reported the opposite trend 8,52. This parameter could not be assessed in our study due to limitations in the instrument used (Pentacam), and this is considered a limitation of the study. Another limitation is that the 6 month follow up period adopted in our study may not be sufficient for capturing all or most changes in the posterior surface, and longer follow up would be useful in further studies.

After each of the three LVCs considered, the central posterior surface flattened, and the paracentral and peripheral regions became steeper. These changes, which have been observed in different zones of the posterior surface during post-operation follow-up, are thought to be the result of a combined effect of tissue subtraction and corneal biomechanical rebalancing.

**Figure Captions:**

**Figure 1** Changes in mean corneal curvature (M) in different corneal regions and in eyes across three surgery groups

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**Figure 1** Changes in mean corneal curvature (M) in different corneal regions and in eyes across the three surgery groups

**Table Captions:**

**Table 1** Baseline characteristics within the three LVC groups

**Table 2** Changes in mean local spherical equivalent curvature (M) of the posterior corneal surface between pre- and post-surgery stages in different corneal regions and across different surgery groups

**Table 1** Baseline characteristics within the three LVC groups

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Biometric parameter | tPRK  (n=65) | FS-LASIK (n=77) | SMILE (n=60) | F | P |
| Age | 27.2±5.2 | 25.5±5.2 | 26.1±6.2 | 1.625 | 0.200 |
| CCT, mm | 538.5±25.6 | 542.6±21.8 | 545.3±16.8 | 1.575 | 0.210 |
| SREC, D | -5.07±1.73 | -5.23±1.35 | -5.03±1.6 | 0.315 | 0.730 |
| CREC, D | -0.73±0.57 | -0.69±0.57 | -0.81±0.54 | 0.791 | 0.455 |
| OZD, mm | 6.55±0.37 | 6.61±0.32 | 6.59±0.2 | 0.631 | 0.533 |
| IOP-DCT, mmHg | 17.26±2.22 | 17.37±2.12 | 17.72±2.08 | 0.805 | 0.448 |
| ASD, µm | 86.42±21.95 | 93.03±19.81 | 106.78±18.86 | 16.356 | 0.000 |
| Flap/Cap thickness, µm | - | 99.83±4.5 | 120.17±3.02 | 948.362 | 0.000 |
| AZD/CAPD, mm | 8.03±0.4 | 7.73±0.38 | 7.64±0.19 | 23.831 | 0.000 |
| RSB, µm | 396.86±37.41 | 346.58±25.32 | 317.97±20.91 | 122.192 | 0.000 |
| SphAb, µm | 0.231±0.07 | 0.233±0.07 | 0.234±0.07 | 0.035 | 0.965 |

ASD, ablated stromal depth, CCT, central corneal thickness; CREC, cylindrical manifest refractive error correction; DCT, Dynamic Contour Tonometer; FS-LASIK, femtosecond laser-assisted excimer laser in situ keratomileusis; IOP, intraocular pressure; OZD, optical zone diameter; AZD, ablation zone diameter, CAPD, cap diameter, RSB, residual stromal bed thickness; SphAb, Spherical aberration; SMILE, small incision stromal lens extraction; SREC, spherical manifest refractive error correction; tPRK, transepithelial photorefractive keratectomy

**Table 2** Changes in mean local spherical equivalent curvature (M) of posterior corneal surface between pre- and post-surgery stages in different corneal regions and across different surgery groups

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | P value | | | | | |
|  | tPRK | FS-LASIK | SMILE | tPRK vs FS-LASIK | tPRK vs SMILE | FS-LASIK vs SMILE | tPRK vs FS-LASIK | tPRK vs SMILE | FS-LASIK vs SMILE |
| Central Area (0–3 mm) | Change between pre and other follow up stages | | | Before ASD correction | | | After ASD correction | | |
| pos1W - pre | 0.015±0.043 | 0.026±0.035 | 0.008±0.033 | 0.281 | 0.865 | 0.019 | 0.569 | 0.126 | 0.002 |
| pos1M - pre | 0.032±0.036 | 0.030±0.031 | 0.018±0.034 | 1.000 | 0.051 | 0.128 | 1.000 | 0.009 | 0.036 |
| pos3M - pre | 0.017±0.032 | 0.029±0.034 | 0.017±0.035 | 0.081 | 1.000 | 0.127 | 0.163 | 1.000 | 0.033 |
| pos6M - pre | 0.010±0.034 | 0.032±0.040 | 0.015±0.039 | 0.003 | 1.000 | 0.031 | 0.005 | 1.000 | 0.021 |
| comparison | 0.000 | 0.470 | 0.146 | - | - | - | - | - | - |
| Paracentral Area (3–6 mm) | Change between pre and other follow up stages | | | Before ASD correction | | | After ASD correction | | |
| pos1W - pre | 0.000±0.049 | -0.017±0.038 | -0.016±0.030 | 0.034 | 0.071 | 1.000 | 0.067 | 0.431 | 1.000 |
| pos1M - pre | 0.009±0.039 | -0.017±0.038 | -0.022±0.035 | 0.000 | 0.000 | 1.000 | 0.000 | 0.003 | 1.000 |
| pos3M - pre | 0.000±0.036 | -0.025±0.039 | -0.024±0.039 | 0.000 | 0.002 | 1.000 | 0.002 | 0.133 | 0.747 |
| pos6M - pre | -0.014±0.035 | -0.029±0.045 | -0.028±0.046 | 0.093 | 0.190 | 1.000 | 0.197 | 1.000 | 1.000 |
| comparison | 0.003 | 0.022 | 0.109 | - | - | - | - | - | - |
| Peripheral Area (6–9 mm) | Change between pre and other follow up stages | | | Before ASD correction | | | After ASD correction | | |
| pos1W - pre | -0.081±0.112 | -0.061±0.066 | -0.013±0.087 | 0.565 | 0.000 | 0.006 | 0.555 | 0.000 | 0.007 |
| pos1M - pre | -0.051±0.097 | -0.039±0.083 | -0.026±0.097 | 1.000 | 0.382 | 1.000 | 1.000 | 0.306 | 0.984 |
| pos3M - pre | -0.048±0.079 | -0.041±0.073 | -0.035±0.097 | 1.000 | 1.000 | 1.000 | 1.000 | 0.882 | 1.000 |
| pos6M - pre | -0.055±0.083 | -0.029±0.084 | -0.044±0.114 | 0.316 | 1.000 | 1.000 | 0.302 | 1.000 | 1.000 |
| comparison | 0.020 | 0.003 | 0.061 | - | - | - | - | - | - |

FS-LASIK, femtosecond laser-assisted excimer laser in situ keratomileusis; pre, preoperation; pos1w, 1 week postoperation; pos1m, 1 month postoperation; pos3m, 3 months postoperation; pos6m, 6 months postoperation; SMILE, small incision stromal lens extraction; tPRK, transepithelial photorefractive keratectomy

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