**Unintended Changes in Ocular Biometric Parameters during a 6-months Follow-up Period after FS-LASIK and SMILE**

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# Abstract

**Background:** Corneal refractive surgery has become reliable for correcting refractive errors, but it can induce unintended ocular changes that alter refractive outcomes. This study is to evaluate the unintended changes in ocular biometric parameters over a 6-month follow-up period after FS-LASIK and SMILE.

**Methods:** 156 consecutive myopic patients scheduled for FS-LASIK and SMILE were included in this study. Central corneal thickness (CCT), mean curvature of the corneal posterior surface (Kpm), internal anterior chamber depth (IACD) and the length from corneal endothelium to retina (ER) were evaluated before and after surgery over a 6 monthes period.

**Results:** Both the FS-LASIK and SMILE groups (closely matched at the pre-surgery stage) experienced flatter Kpm, shallower IACD and decreased ER 1 week post-surgery (p< 0.01), and these changes were larger in FS-LASIK than in SMILE group. During the 1 week to 6 months follow up period, Kpm, IACD and ER remained stable unlike CCT which increased significantly (p< 0.05), more in the FS-LASIK group.

**Conclusions:** During the follow up, the posterior corneal surface becomes flatter and shifts posteriorly, the anterior chamber depth and the length from corneal endothelium to retina decreases significantly compared with the pre surgery stage. These unintended changes in ocular biometric parameters were greater in patients undergoing FS-LASIK than SMILE. The changes present clear challenges for IOL power calculations and should be considered to avoid affecting the outcome of cataract surgery.

**Keywords**: posterior corneal surface, internal anterior chamber depth, the length from corneal endothelium to retina, FS-LASIK, SMILE

# Background

In corneal laser vision correction surgery for myopic patients, the cornea is reshaped with the aim to reach emmetropia. One way to achieve the desired reshaping is using excimer laser to ablate the anterior corneal tissue with or without a flap, in laser in situ keratomileusis (LASIK) or photorefractive keratectomy (PRK), respectively{Farah, 1998 #355} [1](#_ENREF_1). Another way is by removing a stromal lenticule underneath a corneal cap in a procedure called small incision lenticule extraction (SMILE) [2](#_ENREF_2).

In these procedures, most of corneal reshaping takes place in the anterior surface, which is directly affected by the surgery and becomes flattened, compensating the imbalance between corneal curvature and axial length that exists in myopic patients [3](#_ENREF_3). However, changes in the posterior surface have been reported in the literature in the three procedures [4](#_ENREF_4), [5](#_ENREF_5). These posterior changes impact the calculation of the keratometric index of refraction, reducing the accuracy of the intraocular lens power calculation [6](#_ENREF_6). The detection of iatrogenic ectasia whose early diagnosis relies on the posterior surface topography is also affected by these post-surgery changes [7](#_ENREF_7).

Changes in corneal posterior shape and ocular biometric parameters are unintended and result from surgical procedures that are only planned to affect the anterior corneal surface. This study aims to assess the indirect effects of FS-LASIK and SMILE on the corneal posterior shape through measurement of ocular biometric parameters that can influence the overall refractive power and the satisfaction of patients post refractive surgeries.

# Methods

## Patients

This retrospective comparative cases series was approved by the Ethics Committee of the Eye Hospital, Wenzhou Medical University. Written informed consent was provided by all participants that were included in this study. Medical records of patients that underwent refractive surgery by either FS-LASIK or SMILE methods from October 2016 to September 2018 were reviewed. The inclusion criteria were the presence of myopia accompanied or not by astigmatism of less than 3.25D, with resulting manifest spherical equivalent (MSE) not below -10.00D, minimum age of 18 years old, absence of ocular diseases other than the refractive error and no records of complications during or after the procedure. All patients underwent complete ophthalmic examination and those soft contact lens wearers were asked to stop the use of the lens for two weeks. From the 150 cases selected, 77 patients underwent FS-LASIK surgery and 73 received SMILE surgery. Patients from each group were further subdivided according to the MSE, into low to moderate myopia group (LM), MSE ≥ -5.00D (FS-LASIK 26 eyes, SMILE 33 eyes) and high myopia group (HM), MSE < -5.00D (FS-LASIK 51 eyes, SMILE 40 eyes).

In the FS-LASIK procedure, 100 to 110 μm thick flap with a superior 45°wide hinge was created using a femtosecond IntraLase IFS150 laser machine (Abbott Medical Optics, CA, USA). This step was followed by tissue ablation using an Amaris 750 excimer laser (Schwind eye-tech-solutions, Kleinostheim, Germany). SMILE was performed using the VisuMax femtosecond laser system (Carl Zeiss Meditec AG, Jena, Germany), and the laser settings were as follows: 120 μm intended cap thickness, 6.0 to 6.9 mm optical zone (lenticule diameter), and a 2-mm side cut at the 10-0’clock position. Refractive error correction (REC) and optical zone diameter (OZD) for FS-LASIK and SMILE were recorded.

## Measurements and data

The Lenstar LS 900 (Hagg-Streit AG, Koeniz, Switzerland), a non-contact biometry device, was employed in this study to simultaneously image the cornea, internal anterior chamber, central crystalline lens and fovea. The device is based on optical low coherence reflectometry (OLCR) technology using a broad-band light source (20-30 nm), with a central wavelength of 820 mm. The repeatability of the Lenstar’s axial biometric parameter measurements is reported to be excellent, precision of axial length was 0.02~0.03 mm in axial length measurement of normal eyes [8](#_ENREF_8), [9](#_ENREF_9),and the within-subject standard deviation (Sw) was 2.9 μm [10](#_ENREF_10) in CCT measurement after LASIK. Measurements with the Lenstar included central cornea thickness (CCT), internal anterior chamber depth (IACD) and the distance from corneal endothelium to retina (ER), Figure 1.

The mean curvature of corneal posterior surface (Kpm, the mean of curvatures in horizontal and vertical directions over the central 3 mm diameter zone) was provided by a Pentacam (OCULUS Optikgerate GmbH, Wetzlar, Germany). Manifest refractive error was measured with a phoroptor (Nidek RT-2100; Nidek Inc, Gamagori, Japan). The Dynamic Contour Tonometer (DCT, SMT Swiss Microtechnology AG, Switzerland) was employed in this study for intraocular pressure measurement (IOP). Two experienced examiners (SC and HCL) performed all scans in 30-minute sessions held between 09:00 and 17:00. All measurements were taken before surgery (pre), and 1 week (pos1w), 1 month (pos1m), 3 months (pos3m) and 6 months (pos6m) after surgery. The wound healing effect was expected to have stabilized around 6 months after the surgery and therefore this period was used in follow up in earlier studies [11](#_ENREF_11), [12](#_ENREF_12). Three consecutive Pentacam and Lenstar measurements were taken per sitting for both eyes in a dimly lit room without pupillary dilation, and the mean of the three measurements taken for each right eye was used in the statistical analysis.

## Statistical analysis

All analyses were performed using the PASW Statistics 20.0 (SPSS Inc., Chicago, USA). After confirming the presence of normal distribution in the studied groups, comparisons of age, IOP, REC and OZD between the two surgery groups for different MSE subgroups were performed using the One-way ANOVA in each subgroup, while the comparison of MSE, CCT, Kpm, IACD and ER in the LASIK and SMILE surgery groups in different pre and postoperative periods were performed using the MANOVA of repeated measurements. Multiple linear regression analyses with the stepwise method were used to identify significant associations of CCT, REC and OZD with the Kpm differences between pre and post-operation stages. p values less than 0.05 were considered indicative of statistical significance.

# Results

No significant difference between FS-LASIK and SMILE groups was observed in baseline parameters: age, gender, preoperative IOP, REC, OZD, Kpm, CCT and the biometric IACD and ER (p > 0.05). The demographic statistics are summarised in table 1 and the biometric parameters’ baseline values and variations during follow-up are displayed in table 2.

The longitudinal analysis showed different behaviours between FS-LASIK and SMILE in the MSE. While both LM and HM subgroups presented postop stable MSE over 6m after SMILE, the MSE of patients that underwent FS-LASIK reduced significantly from 1w to 1m (p< 0.05) and then became stable until the 6th month (p> 0.05). The comparison of MSE values between the procedures was only significant at the first week in the HM group (p< 0.05).

Regarding CCT, after the initial reduction after both procedures, there was a gradual increase until the end of the follow-up period. This increase was higher in FS-LASIK than in SMILE in both LM and HM subgroups. Considering the period between the first week and the 6th month post-surgery, the LM subgroup presented increases in CCT of 8.9±6.3 µm in FS-LASIK and 3.7±8.3 µm in SMILE, while in the HM subgroup the increase was 11.6±6.6 µm in FS-LASIK and 8.1±9.3 in SMILE.

Small flattening (increase in the negative posterior curvature) was observed one week after each procedure, and that flattening remained stable thereafter. The changes in Kpm between pre and pos1w were higher (p< 0.01) in FS-LASIK group (0.03±0.03 D, 0.49±0.55%) than in SMILE group (0.01±0.03 D, 0.16±0.53%). The Kpm were also higher (p< 0.01) in both HM subgroups than in LM subgroups (0.03±0.04 D, 0.40±0.56% vs 0.01±0.03 D, 0.19±0.55%). No further significant change in posterior curvature was observed within the rest of the follow-up period (p> 0.05) in both groups.The results also showed significant reductions in IACD one week after surgery (p< 0.05) in both procedures. Over the rest of follow-up, the two surgery groups differed with steady changes in IACD in the SMILE group compared to slight fluctuations in the FS-LASIK group, figure 2. The reduction in IACD between pre and pos1w were higher in FS-LASIK group than in SMILE group (-0.096±0.075 mm vs -0.067±0.068 mm) (p< 0.05), while kept similar (p= 0.788) between HM subgroups and LM subgroups. ERdecreased one week after surgery (by -0.019±0.039 mm in FS-LASIK and -0.025±0.032 mm in SMILE) compared with pre surgery stage (p<0.01), then remained stable thereafter, figure 3. The change in ER between pre and pos1w kept similar among two surgery groups (p= 0.354), and no significant change was observed between HM subgroups and LM subgroups (p= 0.728).

Table 3 summarizes the results of multiple linear regression analyses in the study group. The analysis shows that, only the REC and OZD were correlated with the difference in Kpm between pre and pos6m stage.

# Discussion

Corneal refractive surgeries are conceptually designed to correct refractive errors through reshaping the anterior surface, which accounts for most of the corneal refractive power. However, since the surgical procedures affect corneal biomechanics (through tissue separation, ablation and triggering of wound healing), the cornea may experience additional deformation under the same IOP, causing shape changes in the posterior surface. This study aimed to characterize these unintended changes that play an important in the surgical outcome through analysis of clinical data obtained before and after FS-LASIK and SMILE surgeries.

The main results of this study indicated that:

* The cornea became thicker during follow up after both surgeries;
* The posterior corneal surface became slightly flatter with a posterior shift;
* The anterior chamber depth decreased significantly;
* These effects were lower in low myopia patients than in high myopia patients;
* The effects were larger and more consistent in FS-LASIK than in SMILE.

Up to 6 months follow-up was included in this study, which enabled analysis of the mid-term shape changes following both refractive surgeries and the subsequent wound healing process. For the first main result, thickness measurements, the immediate reductions caused by ablation was followed by slight increases over the 6 months follow up period which is expected due to epithelial thickening at the centre of the cornea due to the myopic ablation [13](#_ENREF_13). However, the increase in corneal thickness was significantly higher in FS-LASIK than in SMILE group (10.7±6.6 μm vs 6.1±9.1 μm), larger in high myopia group than low to moderate myopia group (10.1±8.0 μm vs 6.0±7.9 μm), although the difference might not be clinically relevant. This could be due to a difference in corneal curvature gradient that is known to drive shape changes and epithelial remodelling after refractive surgery [14](#_ENREF_14), [15](#_ENREF_15). Similarly, Ryu’s et al study reported postoperative changes in epithelial thickness that were larger after FS-LASIK surgery than after SMILE [16](#_ENREF_16). Reinstein et al, observed that the difference between the planned tissue removal and the experienced stromal reduction was 8.2 ± 8.0 μm. It has been hypothesized that there is stromal expansion after SMILE which could be at least partially compensated by the lower epithelial thickening [17](#_ENREF_17). This study, however, did not include segmental tomography analysis precluding the ability to perform a separate analysis of epithelial and stromal thicknesses. Therefore, it was not possible to determine if the thickening effect post-surgery has taken place in the epithelium, stoma or both.

The second main result, regarding the mild posterior surface flattening was only significant at the first week postoperative and was higher in FS-LASIK and in the HM group. After this initial flattening, the posterior cornea remained stable in a slightly flatter shape. The level of flattening was correlated with refractive error correction and optical zone diameter. Dupps and Roberts have also observed posterior flattening in an ex-vivo study and proposed a biomechanical mechanism for this finding [18](#_ENREF_18). The variation in correlation between the anterior and posterior ocular surfaces after FS-LASIK and SMILE could result in a difference in corneal refraction index, which if ignored may induce unexpected outcomes for IOL. For this reason, it was suggested to use individualized biometrical IOL formulas in the IOL calculations needed when performing cataract surgery in eyes that have been through corneal refractive surgery [19](#_ENREF_19).

In most of the previous clinical studies, the posterior surface was expressed in terms of its elevation relative to a reference surface. In this study, it was chosen not to rely on the relative elevation as the downward shift of corneal apex caused by corneal ablation introduces changes in the coordinate system used post-surgery and may therefore affect the results. Besides, the region over which the reference surface calculation is conducted – commonly the central 8-9 mm diameter area – does not remain stable after the surgery procedure [20-22](#_ENREF_20). This effect leads to variations in the reference surface (such as the best-fit sphere, BFS) post-surgery, relative to that used pre-surgery, possibly causing further measurement inaccuracies [5](#_ENREF_5), [20](#_ENREF_20). For these reasons, curvature, which depends on the relative position of adjacent points and is not influenced by the change in reference plane was used in this study in order to allow a more realistic appreciation of corneal behavior and the result observed with this strategy was in accordance to the expected change in biomechanical behavior caused by the surgery.

Stronger consistency than the results reported in earlier studies was found in our measurements of other parameters. While earlier studies reported mean reductions in internal anterior chamber depth (IACD) of 0.04 mm at 1 month after surgery [23](#_ENREF_23), 0.02±0.07 mm after 2 months [24](#_ENREF_24) and 0.06±0.05 mm after 6 months [25](#_ENREF_25), our study found significant reductions in IACD at 1 month, 3 months and 6 months compared with pre-operative values of 0.067±0.068mm, 0.066±0.067mm, 0.075±0.077 mm, respectively, p< 0.01. This difference can at least be partly due to a backward shift of the posterior corneal surface.

Interestingly, the length from the endothelium to the front surface of retina (ER or axial length without CCT) decreased at the first week postop and remained stable over the rest of follow up, in opposition to what was reported by Wang et al [26](#_ENREF_26). The reduction in ACD and ER in our results indicates a potential backward movement of the corneal posterior surface. This backward movement could be due to the biomechanical alternations in corneal structure caused by surgery, which would have resulted in steepening of the peripheral cornea and flattening of the central region in accordance with what was proposed by Roberts [27](#_ENREF_27), [28](#_ENREF_28), figure 4. Furthermore, having observed higher hyperopic shift in early postoperative stages after FS-LASIK, this suggests that this procedure may induce a stronger biomechanical change than SMILE, which was considered less invasive.

A few limitations should be noted in the present study. The use of different femtosecond laser in FS-LASIK and SMILE could lead to different flap and cap architectures. While it would have been better to use the same platform for both procedures, this was not possible to incorporate in Wenzhou Eye Hospital surgery routines. Another limitation was the biometric measurements taken with the Lenstar, in which patients were asked to fix their gaze on the target lamp in near distance, which may cause reflex convergence and induction of accommodation. However, these effects were mitigated as the device uses optical low-coherence reflectometry with 820 nm laser diode invisible infrared light to measure ocular biometric parameters, along with a visible fixation target designed to induce relaxation of accommodation.

# Conclusions

After laser visual correction surgery, the cornea has become slightly thicker and its posterior surface has become slightly flatter with significant posterior shift. The two procedures, FS-LASIK and SMILE, have presented different effects on the ocular structure. FS-LASIK seemed to cause more pronounced topographical changes post-surgery than SMILE, possibly due to the stronger structural damage taking place in corneal tissue in the former procedure. These observations were particularly evident in the high myopia group compared with those with low or moderate myopia. These results should help improve the predictability of surgical outcomes and the planning and customization of future procedures.

# Declarations

## Ethics approval and consent to participate

The study followed the tenets of the Declaration of Helsinki and was approved by the Ethics Committee of the Eye Hospital, Wenzhou Medical University. Signed informed consent was obtained from all participants after explaining the procedure.

## Consent for publication

Informed consent was obtained from all patients.

## Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Competing interests

The authors declare that they have no competing interests.

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## Authors' contributions

Design of the study (JW, BL, XZ, FB, AE); Conduct of the study, data collection, analysis and interpretation (HL, SC, SW, RZ, QW, XZ); Manuscript preparation and review (JW, BL, RV, FB, AE). All authors read and approved the final manuscript.

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# References

1. Farah SG, Azar DT, Gurdal C, Wong J. Laser in situ keratomileusis: literature review of a developing technique. *J Cataract Refract Surg* 1998;24:989-1006.

2. Sekundo W, Kunert KS, Blum M. Small incision corneal refractive surgery using the small incision lenticule extraction (SMILE) procedure for the correction of myopia and myopic astigmatism: results of a 6 month prospective study. *Br J Ophthalmol* 2011;95:335-339.

3. JI B. Queratoplastia refractiva. *Estudios e Informaciones Oftalmológicas* 1949;10:2-21.

4. Zhang L, Wang Y. The shape of posterior corneal surface in normal, post-LASIK, and post-epi-LASIK eyes. *Invest Ophthalmol Vis Sci* 2010;51:3468-3475.

5. Zhao Y, Jian W, Chen Y, Knorz MC, Zhou X. Three-Year Stability of Posterior Corneal Elevation After Small Incision Lenticule Extraction (SMILE) for Moderate and High Myopia. *J Refract Surg* 2017;33:84-88.

6. Savini G, Hoffer KJ. Intraocular lens power calculation in eyes with previous corneal refractive surgery. *Eye and vision* 2018;5:18.

7. Smadja D, Santhiago MR, Mello GR, Roberts CJ, Dupps WJ, Jr., Krueger RR. Response of the posterior corneal surface to myopic laser in situ keratomileusis with different ablation depths. *J Cataract Refract Surg* 2012;38:1222-1231.

8. Cruysberg LP, Doors M, Verbakel F, Berendschot TT, De Brabander J, Nuijts RM. Evaluation of the Lenstar LS 900 non-contact biometer. *Br J Ophthalmol* 2010;94:106-110.

9. McAlinden C, Gao R, Yu A, et al. Repeatability and agreement of ocular biometry measurements: Aladdin versus Lenstar. *Br J Ophthalmol* 2017;101:1223-1229.

10. Huang J, Liao N, Savini G, et al. Measurement of central corneal thickness with optical low-coherence reflectometry and ultrasound pachymetry in normal and post-femtosecond laser in situ keratomileusis eyes. *Cornea* 2015;34:204-208.

11. Shetty R, Francis M, Shroff R, et al. Corneal Biomechanical Changes and Tissue Remodeling After SMILE and LASIK. *Invest Ophthalmol Vis Sci* 2017;58:5703-5712.

12. Bao F, Cao S, Wang J, et al. Regional changes in corneal shape over a 6-month follow-up after femtosecond-assisted LASIK. *J Cataract Refract Surg* 2019;45:766-777.

13. Reinstein DZ, Srivannaboon S, Gobbe M, et al. Epithelial thickness profile changes induced by myopic LASIK as measured by Artemis very high-frequency digital ultrasound. *J Refract Surg* 2009;25:444-450.

14. Vinciguerra P, Roberts CJ, Albe E, et al. Corneal curvature gradient map: a new corneal topography map to predict the corneal healing process. *J Refract Surg* 2014;30:202-207.

15. Vinciguerra P, Azzolini C, Vinciguerra R. Corneal curvature gradient determines corneal healing process and epithelial behavior. *J Refract Surg* 2015;31:281-282.

16. Ryu IH, Kim BJ, Lee JH, Kim SW. Comparison of Corneal Epithelial Remodeling After Femtosecond Laser-Assisted LASIK and Small Incision Lenticule Extraction (SMILE). *J Refract Surg* 2017;33:250-256.

17. Reinstein DZ, Archer TJ, Gobbe M. Lenticule thickness readout for small incision lenticule extraction compared to artemis three-dimensional very high-frequency digital ultrasound stromal measurements. *J Refract Surg* 2014;30:304-309.

18. Dupps WJ, Jr., Roberts C. Effect of acute biomechanical changes on corneal curvature after photokeratectomy. *J Refract Surg* 2001;17:658-669.

19. Alio JL, Abdelghany AA, Abdou AA, Maldonado MJ. Cataract surgery on the previous corneal refractive surgery patient. *Surv Ophthalmol* 2016;61:769-777.

20. Wang B, Zhang Z, Naidu RK, et al. Comparison of the change in posterior corneal elevation and corneal biomechanical parameters after small incision lenticule extraction and femtosecond laser-assisted LASIK for high myopia correction. *Cont Lens Anterior Eye* 2016;39:191-196.

21. Bao F, Chen H, Yu Y, et al. Evaluation of the shape symmetry of bilateral normal corneas in a Chinese population. *PLoS One* 2013;8:e73412.

22. Ciolino JB, Khachikian SS, Cortese MJ, Belin MW. Long-term stability of the posterior cornea after laser in situ keratomileusis. *J Cataract Refract Surg* 2007;33:1366-1370.

23. Nishimura R, Negishi K, Dogru M, et al. Effect of age on changes in anterior chamber depth and volume after laser in situ keratomileusis. *J Cataract Refract Surg* 2009;35:1868-1872.

24. Cairns G, Ormonde SE, Gray T, et al. Assessing the accuracy of Orbscan II post-LASIK: apparent keratectasia is paradoxically associated with anterior chamber depth reduction in successful procedures. *Clinical & experimental ophthalmology* 2005;33:147-152.

25. Hashemi H, Mehravaran S. Corneal changes after laser refractive surgery for myopia: comparison of Orbscan II and Pentacam findings. *J Cataract Refract Surg* 2007;33:841-847.

26. Wang L, Guo HK, Zeng J, Jin HY. Analysis of changes in crystalline lens thickness and its refractive power after laser in situ keratomileusis. *International journal of ophthalmology* 2012;5:97-101.

27. Roberts C. The cornea is not a piece of plastic. *J Refract Surg* 2000;16:407-413.

28. Roberts C. Biomechanical customization: the next generation of laser refractive surgery. *J Cataract Refract Surg* 2005;31:2-5.



**Figure** 1 Sketch of ocular globe showing main biometric dimensions including internal anterior chamber depth, IACD and distance from corneal endothelium to retina, ER



**Figure 2** Primal value (A) and change (B) in internal anterior chamber depth (IACD) pre-operation and at different stages post FS-LASIK and SMILE. FS-LASIK means femtosecond laser-assisted laser in situ keratomileusis and SMILE means small incision lenticule extraction, while pos1w, pos1m, pos3m and pos6m mean 1 week, 1 month, 3 months and 6 months post-operation; LM means Low to Moderate myopia group and HM means High myopia group.

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**Figure 3** Primal value (A) and change (B) in the length from corneal endothelium to retina (ER) pre-operation and at different stages post FS-LASIK and SMILE. FS-LASIK means femtosecond laser-assisted laser in situ keratomileusis, SMILE means small incision lenticule extraction, while pos1w, pos1m, pos3m and pos6m mean 1 week, 1 month, 3 months and 6 months post-operation; LM means Low to Moderate myopia group and HM means High myopia group.



**Figure 4** Change in posterior corneal surface because of biomechanical alternations in corneal structure caused by refractive surgery

**Table 1** Matched basic information for the two surgery groups

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Biometric parameter | Subgroups | FS-LASIK | SMILE | p |
| age | LM group | 26.93±5.17 | 26.09±5.92 | 0.567 |
| HM group | 26.41±4.73 | 26.50±4.52 | 0.930 |
| gender ratio | LM group | 10/16 | 17/16 | 0.431 |
| HM group | 24/27 | 17/23 | 0.678 |
| IOP, mmHg | LM group | 17.63±1.29 | 18.04±3.07 | 0.146 |
| HM group | 18.03±2.37 | 18.43±2.14 | 0.509 |
| REC, D | LM group | -3.85±0.87 | -3.97±0.74 | 0.708 |
| HM group | -6.39±0.79 | -6.71±1.14 | 0.230 |
| OZD, mm | LM group | 6.80±0.28 | 6.71±0.09 | 0.114 |
| HM group | 6.57±0.25 | 6.49±0.25 | 0.095 |

FS-LASIK = femtosecond laser-assisted laser in situ keratomileusis; SMILE = small incision lenticule extraction; gender ratio= Male/Female; IOP means IOP measurement carried by DCT; REC = refractive error correction; OZD = optical zone diameter; LM group = Low to Moderate myopia group; HM group = High myopia group.

**Table 2** Ocular biometric parameters before and after corneal refractive surgery

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variable | Refractive Status | Surgery Group | pre | pos1w | pos1m | pos3m | pos6m | pre vs pos1w | pos1w vs pos6m |
| MSE | LM | FS-LASIK | -3.85 ± 0.87 | 0.29 ± 0.30 | 0.18 ± 0.38 | 0.11 ± 0.28 | 0.22 ± 0.29 | 0.000 | 1.000 |
| SMILE | -3.97 ± 0.74 | 0.23 ± 0.39 | 0.25 ± 0.39 | 0.28 ± 0.35 | 0.23 ± 0.3 | 0.000 | 1.000 |
| HM | FS-LASIK | -6.39 ± 0.79 | 0.25 ± 0.43 | 0.21 ± 0.41 | 0.13 ± 0.50 | 0.11 ± 0.45 | 0.000 | 0.099 |
| SMILE | -6.71 ± 1.14 | 0.01 ± 0.47 | 0.03 ± 0.47 | -0.02 ± 0.4 | 0.05 ± 0.38 | 0.000 | 1.000 |
| Kpm | LM | FS-LASIK | -6.31 ± 0.17 | -6.30 ± 0.19 | -6.29 ± 0.18 | -6.29 ± 0.17 | -6.30 ± 0.18 | 0.911 | 1.000 |
| SMILE | -6.20 ± 0.28 | -6.19 ± 0.28 | -6.20 ± 0.26 | -6.20 ± 0.28 | -6.19 ± 0.27 | 1.000 | 1.000 |
| HM | FS-LASIK | -6.27 ± 0.21 | -6.24 ± 0.21 | -6.23 ± 0.21 | -6.24 ± 0.22 | -6.23 ± 0.20 | 0.000 | 1.000 |
| SMILE | -6.32 ± 0.25 | -6.32 ± 0.25 | -6.31 ± 0.25 | -6.30 ± 0.25 | -6.30 ± 0.25 | 0.561 | 1.000 |
| CCT | LM | FS-LASIK | 545.08 ± 24.21 | 465.92 ± 36.71 | 469.77 ± 36.68 | 473.88 ± 37.11 | 474.85 ± 38.38 | 0.000 | 0.000 |
| SMILE | 545.48 ± 20.34 | 464.21 ± 19.93 | 462.58 ± 19.38 | 467.15 ± 18.03 | 467.88 ± 19.6 | 0.000 | 0.072 |
| HM | FS-LASIK | 548.94 ± 32.66 | 434.49 ± 34.3 | 438.12 ± 34.99 | 443.53 ± 34.02 | 446.08 ± 33.94 | 0.000 | 0.000 |
| SMILE | 552.65 ± 19.97 | 440.40 ± 20.09 | 442.15 ± 19.17 | 447.53 ± 18.49 | 448.53 ± 18.61 | 0.000 | 0.000 |
| IACD | LM | FS-LASIK | 3.14 ± 0.27 | 3.05 ± 0.27 | 3.07 ± 0.29 | 3.06 ± 0.29 | 3.05 ± 0.28 | 0.000 | 1.000 |
| SMILE | 3.15 ± 0.22 | 3.07 ± 0.23 | 3.08 ± 0.22 | 3.08 ± 0.23 | 3.07 ± 0.21 | 0.000 | 1.000 |
| HM | FS-LASIK | 3.21 ± 0.25 | 3.11 ± 0.26 | 3.14 ± 0.26 | 3.15 ± 0.26 | 3.13 ± 0.26 | 0.000 | 0.100 |
| SMILE | 3.19 ± 0.21 | 3.13 ± 0.21 | 3.13 ± 0.21 | 3.13 ± 0.20 | 3.14 ± 0.20 | 0.000 | 1.000 |
| ER | LM | FS-LASIK | 24.57 ± 0.71 | 24.54 ± 0.71 | 24.55 ± 0.71 | 24.54 ± 0.72 | 24.53 ± 0.73 | 0.000 | 1.000 |
| SMILE | 24.98 ± 0.88 | 24.96 ± 0.88 | 24.95 ± 0.89 | 24.95 ± 0.89 | 24.96 ± 0.89 | 0.047 | 1.000 |
| HM | FS-LASIK | 25.69 ± 0.79 | 25.68 ± 0.79 | 25.68 ± 0.79 | 25.69 ± 0.79 | 25.7 ± 0.79 | 0.065 | 0.585 |
| SMILE | 25.67 ± 0.99 | 25.67 ± 0.99 | 25.64 ± 0.99 | 25.62 ± 0.98 | 25.62 ± 0.98 | 0.000 | 1.000 |

MSE = spherical equivalent refraction, Kpm = mean corneal curvature of posterior surface, CCT = central corneal thickness, IACD= internal anterior chamber; ER = distance from corneal endothelium to retina; LM Group=Low to Moderate myopia Group, HM Group=High myopia Group

**Table 3** The stepwise multiple linear regression models for IOP differences between pre and post-operation stage

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Dependent Variables | Parameters | Β a | P value | Regression Equation | Adjusted R2 | F b | P value |
| ∆Kpm-prepos6m | REC | -0.282 | 0.003 | ∆Kpm-prepos6m = -0.007 x REC(D) + 0.030 x OZD(mm) – 0.214 (D) | 0.251 | 4.783 | 0.010 |
|  | OZD | 0.200 | 0.034 |  |  |  |  |

∆ means the difference between pre and post operation stages; prepos6m means the difference between pre and pos6m stage; Kpm means mean curvature of the corneal posterior surface; a means Standardized Coefficients (Beta); b means Multiple Linear Regression Model (Stepwise)