

Comparison of Visual Outcomes Following Ray-Tracing-Guided Femtosecond Laser-Assisted in Situ Keratomileusis with Different Optical Zone Sizes

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Abstract

Purpose: To evaluate the impact of different optical zone (OZ) size on clinical outcomes following ray-tracing-guided femtosecond laser-assisted in situ keratomileusis (FS-LASIK).

Methods: A total of 126 eyes of 63 patients were stratified by intended OZ size: 6.5- group (6.0-6.5 mm) and 6.5+ group (6.6-7.0 mm). Standardized preoperative and 3-month postoperative evaluations included uncorrected (UDVA) and corrected (CDVA) distance visual acuity, manifest refraction, mean keratometry, intended/achieved maximum ablation depth, central corneal thickness, low-mesopic pupil diameter, 6-mm total ocular wavefront aberrations, and the Quality of Vision (QoV) questionnaire.

Results: Both groups achieved excellent refractive accuracy and stability. No significant differences were observed in spherical equivalent, refractive or surgically induced astigmatism, difference vector, mean keratometry, central corneal thickness, maximum ablation depth, or QoV scores (all $P > .05$). At 3 months, 80% of the 6.5- group and 76% of the 6.5+ group achieved UDVA of 20/16 or better ($P = .797$). The 6.5+ group demonstrated significantly lower total ocular wavefront aberrations, including higher-order aberrations (HOAs; $P = .005$), spherical aberration ($P = .016$), coma ($P = .013$), and vertical coma ($P = .023$).

Conclusion: A larger OZ (6.6-7.0 mm) yields visual and refractive outcomes comparable to those of a smaller OZ, while significantly reducing HOAs. Selecting a larger OZ is a promising strategy for improving postoperative optical quality without compromising visual acuity or refractive precision.

Trial Registration: Chinese Clinical Trial Registry (ChiCTR2500107271), retrospectively registered on August 7th, 2025.

Introduction

Over the past three decades, corneal refractive surgery has evolved into a well-established treatment modality with global acceptance.¹ Among available techniques, femtosecond laser-assisted in situ keratomileusis (FS-LASIK) has evolved into a predominant and widely adopted procedure.² Advances in surgical theory, diagnostics, and laser technology have driven the evolution of sophisticated excimer ablation profiles, such as Q-value-adjusted and topography-guided treatments, which are predominantly based on the Gullstrand simplified eye model.³ Currently, there is a growing clinical demand for safer and more effective refractive surgeries. Consequently, the development of increasingly customised ablation approaches is being vigorously pursued.

In 2008, Mrochen et al. proposed a novel approach to laser vision correction by introducing a ray-tracing-based ablation profile grounded in a comprehensive optical model of the entire eye.⁴ Departing from conventional strategies reliant on the simplified eye model, the ray-tracing-guided FS-LASIK platform (WaveLight Plus; Alcon Laboratories, Inc.) simulates the trajectory of discrete light rays as they traverse all refractive ocular structures.⁵ This facilitates the derivation of a patient-specific ablation profile optimized for foveal focusing, thereby supporting a highly individualized treatment strategy.⁶ The InnovEyes Sightmap diagnostic system employs an automated ray-tracing algorithm designed to correct both lower- and higher-

order aberrations (HOAs) concurrently. This algorithm is integrated with an advanced precompensation model that incorporates key surgical related variables, including laser ablation efficiency, anticipated corneal biomechanical responses, and epithelial remodeling.^{7,8} In contrast to conventional LASIK, the WaveLight Plus platform utilizes exclusively objective measurement data, which helps streamline preoperative planning, reduce manual input errors, and potentially enhance refractive predictability. Consistent with these technical advantages, previous clinical studies have reported favorable visual and refractive outcomes following ray-tracing-guided FS-LASIK.⁸⁻¹⁰

larger optical zone (OZ) is known to reduce visual disturbances such as glare and halos, it requires deeper corneal ablation. To assess the net clinical benefit of this trade-off in ray-tracing-guided FS-LASIK, we conducted a retrospective comparative study evaluating the effect between two groups defined by OZ size.

Methods

Patients

This study received approval from the Ethics Committee of Guangzhou Aier Hospital (Approval No.GZAIER-2024-IRB-42) and conducted in accordance with the tenets of the Declaration of Helsinki. The study cohort consisted of consecutive patients who underwent ray-tracing-guided FS-LASIK at our institution between January and May 2025.

Ophthalmic Examination Protocol

All patients underwent comprehensive ophthalmic examinations preoperatively and at the 3-month postoperative visit. Evaluations included uncorrected distance visual acuity (UDVA), corrected distance visual acuity (CDVA), manifest refraction (both non-cycloplegic and cycloplegic), non-contact tonometry, slit-lamp biomicroscopy, low-mesopic pupil diameter measurement, and dilated fundus examination. In addition, corneal tomography, whole-eye aberrometry, wavefront refraction, and biometric data were obtained using the Pentacam and InnovEyes SightMap systems. All measurements were performed by a single experienced technician to ensure consistency and minimize inter-observer variability. The Quality of Vision (QoV) questionnaire was administered at the 3-month postoperative visit.

Surgical Procedure

A standardized corneal flap (110 µm; 8.5 mm) was created using the WaveLight FS200 laser (Alcon), and ablation was carried out with the WaveLight EX500 (Alcon). The ablation profile, generated solely by WaveLight Plus software, employed OZ sizes of 6.0-6.5 mm (6.5- group) or 6.6-7.0 mm (6.5+ group), with emmetropia as the universal target.

Statistical Analysis

Statistical analyses were performed using Microsoft Excel 2019 (Microsoft Corporation) and SPSS version 27.0 (IBM Corporation). To account for inter-eye correlation, generalized estimating equations were applied

for both inter-group and intra-group comparisons.¹¹ Categorical outcomes from QoV questionnaire were assessed using Fisher's exact test. A *P*-value of < .05 was defined as statistically significant.

Results

Patient Baseline Characteristics

Of the 126 eyes enrolled and stratified by OZ size, 60 were assigned to the 6.5- group and 66 to the 6.5+ group. No surgical complications occurred. Preoperative characteristics are summarized in Table 1. No significant differences were observed between the groups in terms of age, gender, CDVA, SEQ, mean keratometry, attempted ablation maximum thickness, central corneal thickness, or low-mesopic pupil diameter (all *P* > .05), confirming their comparability prior to surgery.

Visual and Refractive Outcomes and Cornea Parameters

Postoperative visual, refractive, and corneal outcomes at 3 months are summarized in Table 2 and Figure 1 (generated using mEYEstro standard outcomes software¹²). The two groups showed no significant differences in logMAR UDVA (*P* = .936), SEQ (*P* = .545), mean keratometry (*P* = .468), achieved ablation maximum thickness of cornea (*P* = .307), or central corneal thickness (*P* = .628).

Visual acuity outcomes are summarized in Figures 1A-1C. As shown in Figure 1A, 80% of eyes (48/60) in the 6.5- group and 76% (50/66) in the 6.5+ group achieved a postoperative UDVA of 20/16 or better (*P* = .797). Figure 1B shows that 65% (39/60) of the 6.5- group and 55% (36/66) of the 6.5+ group gained one or more Snellen lines in UDVA compared with preoperative CDVA (*P* = .080). The efficacy index was comparable between groups (1.17 ± 0.14 vs. 1.14 ± 0.16 , *P* = .342). Regarding safety (Figure 1C), 97% (58/60) of the 6.5- group and 98% (64/66) of the 6.5+ group maintained or gained at least one line of CDVA, with no significant difference in safety index (1.17 ± 0.14 vs. 1.15 ± 0.15 , *P* = .551).

The 6.5+ group exhibited a trend toward greater ablation depth than the 6.5- group (106.78 ± 24.08 μ m vs. 101.78 ± 26.30 μ m, *P* = .307). Postoperative mean keratometry (*P* = .468) and central corneal thickness (*P* = .628) were comparable between groups.

Predictability

Postoperative refractive accuracy at 3 months is detailed in Figures 1D-1F. The proportion of eyes within ± 0.50 D of emmetropia was 91.7% in the 6.5- group and 84.8% in the 6.5+ group (Figure 1D). A slight overcorrection was noted, with a mean SEQ of 0.07 ± 0.35 D in the 6.5- group compared to 0.13 ± 0.45 D in the 6.5+ group (*P* = .584). As shown in Figure 1E, attempted and achieved SEQ exhibited a strong linear correlation in both groups ($R^2 = 0.94$ for the 6.5- group and $R^2 = 0.91$ for the 6.5+ group). Refractive stability outcomes (Figure 1F) revealed that 11.67% of eyes in the 6.5- group and 24.24% in the 6.5+ group had a change exceeding 0.50 D (*P* = .068).

Astigmatic outcomes are presented in Figure 1G. Postoperative refractive astigmatism of ≤ 0.50 D was achieved in 93.3% (56 eyes) of the 6.5- group and 93.9% (62 eyes) of the 6.5+ group. The mean

postoperative astigmatism was 0.23 ± 0.22 D in the 6.5- group and 0.21 ± 0.24 D in the 6.5+ group, with no statistically significant intergroup difference ($P = .494$).

Vector Analysis

Vector analysis of astigmatic correction at 3 months postoperatively showed no statistically significant differences between the 6.5- and 6.5+ groups (Figures 1H-1J). The comparative results were as follows: refractive astigmatism (RA), 0.23 ± 0.23 D vs. 0.21 ± 0.24 D ($P = .052$); target-induced astigmatism (TIA), 0.97 ± 0.51 D vs. 0.82 ± 0.41 D ($P = .158$); surgically induced astigmatism (SIA), 1.08 ± 0.53 D vs. 0.91 ± 0.54 D ($P = .052$); correction index (CI), 1.14 ± 0.33 vs. 1.01 ± 0.40 ($P = .252$); and angle of error, $-1.11^\circ \pm 9.02^\circ$ vs. $-0.95^\circ \pm 17.03^\circ$ ($P = .383$).

Changes in Ocular Aberrations

Ocular aberration changes under a 6 mm pupil diameter are summarized in Figure 2 and Supplementary Tables 1-3. Prior to surgery, the two groups showed no statistically significant differences in any aberration metrics-including HOAs, spherical aberration, coma, vertical coma, horizontal coma, vertical trefoil, or horizontal trefoil (all $P > .05$).

At 3 months postoperatively, the 6.5+ group demonstrated significantly lower values than the 6.5- group in several key aberration metrics: HOAs ($P = .005$), coma ($P = .013$), and vertical coma ($P = .023$). We also observed that the 6.5+ group demonstrated a smaller absolute magnitude of spherical aberration compared to the 6.5- group ($P = .016$), with its mean value shifting slightly into the negative range. In contrast, no significant inter-group differences were observed for horizontal coma ($P = .720$), vertical trefoil ($P = .492$), or horizontal trefoil ($P = .607$). Furthermore, the 6.5+ group demonstrated a significantly smaller magnitude of change (postoperative minus preoperative) in HOAs ($P = .011$) and coma ($P = .011$) compared to the 6.5- group (Figure 2; Supplementary Table 1).

The within-group analysis, summarized in Figure 2A and Supplementary Tables 2-3, revealed that the 6.5- group showed a significant postoperative increase in HOAs ($P < .001$), coma ($P < .001$), vertical coma ($P < .001$), and horizontal coma ($P = .017$) compared to preoperative levels. In contrast, the 6.5+ group exhibited a significant postoperative increase in coma and vertical coma, alongside a significant reduction in spherical aberration (all $P < .001$).

QoV Questionnaire Scores

Despite significantly lower total ocular aberrations-including HOAs, spherical aberration, coma, and vertical coma in the 6.5+ group, this objective optical improvement did not correspond to enhanced subjective visual quality. The two groups reported similar ratings for the frequency, severity, and bothersome impact of various visual symptoms (Figures 3), including glare, fluctuations in vision, halos, blurred vision, focusing difficulties, hazy vision, starburst, double or multiple images, difficulty judging distance or depth perception and distortion (all $P > .05$).

Discussion

Over the past three decades, numerous excimer laser ablation algorithms have been developed to improve refractive outcomes. Among these, ray-tracing-guided FS-LASIK is unique in utilizing a fully individualized virtual whole-eye optical model and has been associated with favorable visual results in several studies.^{4,13-15} To our knowledge, this study provides the first systematic evaluation of how OZ size affects visual quality after ray-tracing-guided FS-LASIK. The two treatment strategies achieved comparable refractive accuracy and stability. The larger OZ significantly reduced total ocular wavefront aberrations, including HOAs, spherical aberration, coma, and vertical coma. Other endpoints—visual acuity, refractive stability, safety parameters, and subjective QoV questionnaire scores—remained similar between the two groups.

The refractive outcomes observed in the current study align with the well-documented efficacy of ray-tracing-guided FS-LASIK. Previous reports have consistently demonstrated high levels of visual and refractive precision with this platform. Schumacher et al. noted that 83.8% of eyes achieved a UDVA of 20/20 or better three months postoperatively, with a mean SEQ of 0.03 ± 0.30 D and 87.4% of eyes within ± 0.50 D of target refraction.¹⁶ Similarly, Khoramnia et al. reported that all treated eyes attained a postoperative UDVA of 20/20, with SEQ outcomes consistently within ± 0.50 D.¹⁷ Cummings et al. further substantiated that ray-tracing guidance yields significantly better UDVA and refractive predictability compared to other individualized FS-LASIK platforms.⁶ In a large real-world cohort, He et al. observed that at three months, all eyes achieved UDVA $\geq 20/20$, with a mean SEQ of 0.12 ± 0.28 D across 400 eyes.¹⁸ Consistent with these earlier findings, the present analysis revealed a mean SEQ of 0.07 ± 0.35 D in the 6.5- group and 0.13 ± 0.45 D in the 6.5+ group, with 98% and 95% of eyes, respectively, achieving UDVA $\geq 20/20$. This agreement across independent studies underscores the reproducible refractive safety and accuracy of ray-tracing-guided FS-LASIK, reaffirming its position as a reliable and advanced technique for corneal refractive surgery.

The literature consistently identifies postoperative residual refractive error and UDVA as significant determinants of visual disturbances and patient dissatisfaction.^{19,20} Within this framework, the corneal effective OZ—defined as the functional corneal area responsible for optimal postoperative visual acuity, plays a critical role.²¹ Correspondingly, Moshirfar et al. demonstrated that maintaining a larger surgical effective OZ mitigates the induction of spherical aberration and total HOAs, thereby reducing symptoms such as glare and halos.²² Our findings are consistent with this principle. In the 6.5- group, a significant postoperative increase was observed at 3 months in HOAs, coma, vertical coma, and horizontal coma, whereas spherical aberration decreased significantly. Vertical trefoil and horizontal trefoil remained stable compared to preoperative levels. The 6.5+ group also exhibited a postoperative increase in coma and vertical coma but demonstrated a significant reduction in spherical aberration, which assumed a slightly negative value. Between-group analysis under a 6-mm pupil confirmed that the 6.5+ group had significantly lower values of HOAs, spherical aberration, coma, and vertical coma than the 6.5- group, whereas horizontal coma, vertical trefoil, and horizontal trefoil were comparable between groups. Despite these objective aberration improvements in the 6.5+ group, the QoV questionnaire—recognized as a well-validated tool for assessing post-refractive visual symptoms,²³ showed no significant difference between the two groups. Previous studies have proposed various factors influencing visual symptoms, including pupil size,²⁴ ocular HOAs,²⁵ and the postoperative SEQ,²⁴ though conflicting evidence exists.^{20,26} The dissociation between

objective optical metrics and subjective visual perception observed in our study may be attributed to several mechanisms. First, neural adaptation enables the human visual system to partially compensate for stable optical imperfections over time. Second, once aberrations fall below a certain perceptual threshold, further reduction may not yield discernible subjective benefits. Finally, the QoV questionnaire captures a multidimensional psychophysical construct influenced by non-optical factors such as patient expectations and ambient lighting conditions. According to the Munnerlyn formula, enlarging the OZ increases corneal tissue ablation.²⁷ Although the 6.5+ group showed a trend toward greater ablation depth in our study, this difference did not reach statistical significance. Therefore, the clinical utility and potential advantages of a larger OZ necessitate further validation in future prospective studies with extended follow-up and larger sample sizes.

This study has several limitations including the relatively small sample size in a single-center trial and short follow-up period. Furthermore, the current analysis was confined to visual acuity, refractive outcomes, and aberrations; future studies incorporating contrast sensitivity, or patient satisfaction metrics under various lighting conditions could provide a more comprehensive assessment.

In summary, for myopic correction with ray-tracing-guided FS-LASIK, a larger OZ size (6.6-7.0 mm) yields significantly lower postoperative ocular aberration than a smaller OZ size (6.0-6.5 mm), while providing comparable visual acuity, refractive accuracy, and safety. As this objective advantage did not enhance patient-reported QoV, surgeons should individualize optical zone selection based on a comprehensive preoperative assessment of corneal characteristics and patient-specific goals.

Conclusion

In ray-tracing-guided FS-LASIK, a larger optical zone (6.6-7.0 mm) achieves visual and refractive outcomes comparable to those of a smaller zone, while concurrently yielding a significant reduction in higher-order aberrations. These findings suggest that enlarging the optical zone offers a tangible advantage in optimizing the postoperative optical quality of the corneal surface. Considering that the larger ablation diameter did not compromise safety or refractive precision, this strategy presents a clinically viable approach for myopic patients, particularly those with larger scotopic pupil diameters who are at higher risk for postoperative glare and halo symptoms.

Declarations

Ethics approval and consent to participate: This study adhered to the tenets of the Declaration of Helsinki and was approved by the Ethical Committee Review Board of Guangzhou Aier Eye Hospital (No. GZAIER-2024-IRB-42). Written informed consent was obtained from all participants.

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and analyzed 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: X.B. analyzed data and wrote the original manuscript. L.X. and Z.W. designed the study, supervised experiments, and revised the manuscript critically. J.W. and B.Z. assisted with manuscript revision and provided intellectual feedback. All authors approved the final version.

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Clinical trial registration: ChiCTR2500107271, retrospectively registered on August 7th, 2025.

References

1. Liu S, Zhang X, Niu L, Yu Z, Zhou X, Zhao J. Comparison of the Functional Optical Zone in Eyes With High Myopia With High Astigmatism After SMILE and FS-LASIK. *J Refract Surg.* Sep 2022;38(9):595-601.<https://doi.org/10.3928/1081597X-20220725-01>PMID:36098388
2. Titiyal JS, Goswami A, Kaur M, et al. Impact of Topical Cyclosporine-A or Topical Chloroquine on Post-LASIK Ocular Surface Stability - A Randomized Controlled Trial. *Curr Eye Res.* Jun 2023;48(6):557-563.<https://doi.org/10.1080/02713683.2023.2182747>PMID:36800492
3. Gobbi PG, Carones F, Brancato R. Keratometric index, videokeratography, and refractive surgery. *J Cataract Refract Surg.* Feb 1998;24(2):202-211.[https://doi.org/10.1016/s0886-3350\(98\)80201-0](https://doi.org/10.1016/s0886-3350(98)80201-0)PMID:9530595
4. Mrochen M, Bueeler M, Donitzky C, Seiler T. Optical ray tracing for the calculation of optimized corneal ablation profiles in refractive treatment planning. *J Refract Surg.* Apr 2008;24(4):S446-451.<https://doi.org/10.3928/1081597X-20080401-23>PMID:18500100
5. Kim TI, Alio Del Barrio JL, Wilkins M, Cochener B, Ang M. Refractive surgery. *Lancet.* May 18 2019;393(10185):2085-2098.[https://doi.org/10.1016/S0140-6736\(18\)33209-4](https://doi.org/10.1016/S0140-6736(18)33209-4)PMID:31106754
6. Cummings AB, Kelly GE. Optical ray tracing-guided myopic laser in situ keratomileusis: 1-year clinical outcomes. *Clin Ophthalmol.* 2013;7:1181-1191.<https://doi.org/10.2147/OPTH.S44720>PMID:23807835
7. Kanellopoulos AJ, Maus M, Bala C, et al. International Multicenter, Myopic and Myopic Astigmatism Femto LASIK, Customized by Automated Ray-Tracing Ablation Profile Calculation: A Postmarket Study. *Clin Ophthalmol.* 2024;18:525-536.<https://doi.org/10.2147/OPTH.S435581>PMID:38405105
8. Kanellopoulos AJ. Ray-Tracing Customization in Myopic and Myopic Astigmatism LASIK Treatments for Low and High Order Aberrations Treatment: 2-Year Visual Function and Psychometric Value Outcomes of a Consecutive Case Series. *Clin Ophthalmol.* 2024;18:565-574.<https://doi.org/10.2147/OPTH.S444174>PMID:38410630
9. Yuan Y, Zhang R, Wang Z, Wang Y, Zhang Y, Chen Y. Ray-tracing-Guided or Q-Value-Adjusted FS-LASIK for Correction of Myopia and Myopic Astigmatism: A Comparative Contralateral Eye Study. *J Refract*

- Surg.* Nov 2024;40(11):e804-e813.<https://doi.org/10.3928/1081597X-20240917-01>PMID:39530991
10. Cao X, Zhang J, Shao J, Zhang Y, Zheng L. Study of the InnovEyes Sightmap Platform in Comparing Ray-Tracing-Guided LASIK and Topography-Guided LASIK. *J Refract Surg.* Dec 2024;40(12):e994-e1002.<https://doi.org/10.3928/1081597X-20241030-03>PMID:39656251
 11. Hanley JA, Negassa A, Edwardes MD, Forrester JE. Statistical analysis of correlated data using generalized estimating equations: an orientation. *Am J Epidemiol.* Feb 15 2003;157(4):364-375.<https://doi.org/10.1093/aje/kwf215>PMID:12578807
 12. Gauvin M, Wallerstein A. mEYEstro software: an automatic tool for standardized refractive surgery outcomes reporting. *BMC Ophthalmol.* Apr 21 2023;23(1):171.<https://doi.org/10.1186/s12886-023-02904-6>PMID:37085797
 13. Wang Y, Tang N, Duan Z, et al. Comparison of Subjective and Wavefront-Measured Refractions by InnovEyes Platform in Myopic Patients. *J Refract Surg.* Nov 2024;40(11):e836-e844.<https://doi.org/10.3928/1081597X-20241002-04>PMID:39530982
 14. Thananjeyan AL, Bala C. Higher-Order Aberrations Following Ray Trace LASIK and the Impact of Eye Movement on Coma. *Clin Ophthalmol.* 2024;18:3389-3398.<https://doi.org/10.2147/OPTH.S497131>PMID:39600614
 15. Kanellopoulos AJ. Initial Outcomes with Customized Myopic LASIK, Guided by Automated Ray Tracing Optimization: A Novel Technique. *Clin Ophthalmol.* 2020;14:3955-3963.<https://doi.org/10.2147/OPTH.S280560>PMID:33239861
 16. Schumacher S, Seiler T, Cummings A, Maus M, Mrochen M. Optical ray tracing-guided laser in situ keratomileusis for moderate to high myopic astigmatism. *J Cataract Refract Surg.* Jan 2012;38(1):28-34.<https://doi.org/10.1016/j.jcrs.2011.06.032>PMID:22033124
 17. Khoramnia R, Naujokaitis T, Block L, et al. Prospective Intraindividual Comparison of Automated Customized Ray-Tracing-Guided versus Wavefront-Optimized LASIK. *Ophthalmology.* Oct 2025;132(10):1169-1179.<https://doi.org/10.1016/j.ophtha.2025.05.025>PMID:40482723
 18. He G, Bala C. Ray-tracing-guided myopic LASIK: real-world clinical outcomes. *J Cataract Refract Surg.* Nov 1 2023;49(11):1140-1146.<https://doi.org/10.1097/j.jcrs.0000000000001286>PMID:37595291
 19. Tahzib NG, Bootsma SJ, Eggink FA, Nabar VA, Nuijts RM. Functional outcomes and patient satisfaction after laser in situ keratomileusis for correction of myopia. *J Cataract Refract Surg.* Oct 2005;31(10):1943-1951.<https://doi.org/10.1016/j.jcrs.2005.08.022>PMID:16338565
 20. Schmidt GW, Yoon M, McGwin G, Lee PP, McLeod SD. Evaluation of the relationship between ablation diameter, pupil size, and visual function with vision-specific quality-of-life measures after laser in situ keratomileusis. *Arch Ophthalmol.* Aug 2007;125(8):1037-1042.<https://doi.org/10.1001/archophth.125.8.1037>PMID:17698749
 21. Tabernero J, Klyce SD, Sarver EJ, Artal P. Functional optical zone of the cornea. *Invest Ophthalmol Vis Sci.* Mar 2007;48(3):1053-1060.<https://doi.org/10.1167/iovs.06-0867>PMID:17325146
 22. Moshirfar M, Herron MS, Cha DS, Santos J, Payne CJ, Hoopes PC. Comparing Effective Optical Zones After Myopic Ablation Between LASIK, PRK, and SMILE With Correlation to Higher Order Aberrations. *J*

- Refract Surg.* Nov 2023;39(11):741-750.<https://doi.org/10.3928/1081597X-20231016-02>PMID:37937754
23. Kandel H, Khadka J, Lundstrom M, Goggin M, Pesudovs K. Questionnaires for Measuring Refractive Surgery Outcomes. *J Refract Surg.* Jun 1 2017;33(6):416-424.<https://doi.org/10.3928/1081597X-20170310-01>PMID:28586503
 24. Schallhorn SC, Kaupp SE, Tanzer DJ, Tidwell J, Laurent J, Bourque LB. Pupil size and quality of vision after LASIK. *Ophthalmology.* Aug 2003;110(8):1606-1614.[https://doi.org/10.1016/S0161-6420\(03\)00494-9](https://doi.org/10.1016/S0161-6420(03)00494-9)PMID:12917181
 25. Mrochen M, Kaemmerer M, Mierdel P, Seiler T. Increased higher-order optical aberrations after laser refractive surgery: a problem of subclinical decentration. *J Cataract Refract Surg.* Mar 2001;27(3):362-369.[https://doi.org/10.1016/s0886-3350\(00\)00806-3](https://doi.org/10.1016/s0886-3350(00)00806-3)PMID:11255046
 26. Gyldenkerne A, Ivarsen A, Hjortdal J. Optical and visual quality after small-incision lenticule extraction. *J Cataract Refract Surg.* Jan 2019;45(1):54-61.<https://doi.org/10.1016/j.jcrs.2018.08.026>PMID:30391154
 27. Munnerlyn CR, Koons SJ, Marshall J. Photorefractive keratectomy: a technique for laser refractive surgery. *J Cataract Refract Surg.* Jan 1988;14(1):46-52.[https://doi.org/10.1016/s0886-3350\(88\)80063-4](https://doi.org/10.1016/s0886-3350(88)80063-4)PMID:3339547

Tables

TABLE 1 Characteristics Comparison of Preoperative Parameters in Two Groups.

	6.5-	6.5+	β	SE	95% CI	<i>P</i> value
	Mean $\pm$ SD (Min to Max)	Mean $\pm$ SD (Min to Max)				
Patients (eyes, n)	60, 30	66, 33				
Gender (M/F), n	14/16	21/12	-0.152	0.123	-0.393 to 0.088	0.214
Age	27.40 $\pm$ 4.83 (18 to 33)	25.45 $\pm$ 4.67 (19 to 36)	-1.997	1.160	-4.271 to 0.277	0.085
CDVA (LogMAR)	-0.01 $\pm$ 0.04 (-0.08 to 0.10)	-0.02 $\pm$ 0.04 (-0.08 to 0.05)	-0.005	0.009	-0.022 to 0.012	0.547
SEQ	-5.00 $\pm$ 1.44 (-7.75 to -1.63)	-4.16 $\pm$ 1.46 (-7.25 to -1.25)	0.866	0.316	0.245 to 1.486	0.223
Pre Mean Keratometry (D)	42.90 $\pm$ 1.28 (39.70 to 45.50)	42.91 $\pm$ 1.42 (39.50 to 45.80)	-0.191	0.327	-0.831 to 0.449	0.559
Attempted Ablation Maximum Thickness (μ m)	97.94 $\pm$ 21.56 (49.96 to 148.64)	100.66 $\pm$ 22.43 (54.57 to 146.82)	2.880	4.778	-6.485 to 12.246	0.547
Pre Central Corneal Thickness (μ m)	543.08 $\pm$ 28.78 (502 to 616)	556.02 $\pm$ 30.62 (501 to 620)	20.322	6.921	6.758 to 33.886	0.083
Low-mesopic Pupil Diameter (mm)	6.35 $\pm$ 0.59 (5.25 to 7.75)	6.62 $\pm$ 0.60 (5.50 to 7.75)	0.246	0.149	-0.046 to 0.539	0.098

CDVA = Corrected Distance Visual Acuity; LogMAR =Logarithm of the Minimum Angle of Resolution; SEQ = Spherical Equivalent; D = Diopters; SD = Standard Deviation; SE = Standard Error; CI = Confidence Interval.

TABLE 2 Comparison of Ocular Parameters between the Two Groups at 3 Months Postoperatively.

	6.5-	6.5+	β	SE	95% CI	<i>P</i> value
	Mean ± SD (Min to Max)	Mean ± SD (Min to Max)				
UDVA (LogMAR)	-0.08 ± 0.06 (-0.18 to 0.10)	-0.08 ± 0.07 (-0.18 to 0.10)	0.001	0.140	-0.026 to 0.029	0.936
SEQ	0.08 ± 0.35 (-0.88 to 1.00)	0.13 ± 0.45 (-1.00 to 1.88)	0.053	0.087	-0.118 to 0.224	0.545
Postoperative Mean Keratometry (D)	38.17 ± 1.91 (35.2 to 42.8)	38.69 ± 1.83 (35.0 to 42.9)	0.324	0.446	-0.550 to 1.198	0.468
Achieved Ablation Maximum Thickness (um)	101.78 ± 26.30 (45 to 149)	106.78 ± 24.08 (53 to 157)	5.804	5.649	-5.326 to 16.935	0.307
Postoperative Central Corneal Thickness (um)	441.73 ± 32.03 (393 to 530)	450.45 ± 30.91 (394 to 527)	2.345	4.835	-7.132 to 11.822	0.628

UDVA = Uncorrected Distance Visual Acuity; LogMAR = Logarithm of the Minimum Angle of Resolution; SEQ = Spherical Equivalent; D = Diopters; SD = Standard Deviation; SE = Standard eError; CI = Confidence Interval.

Figures

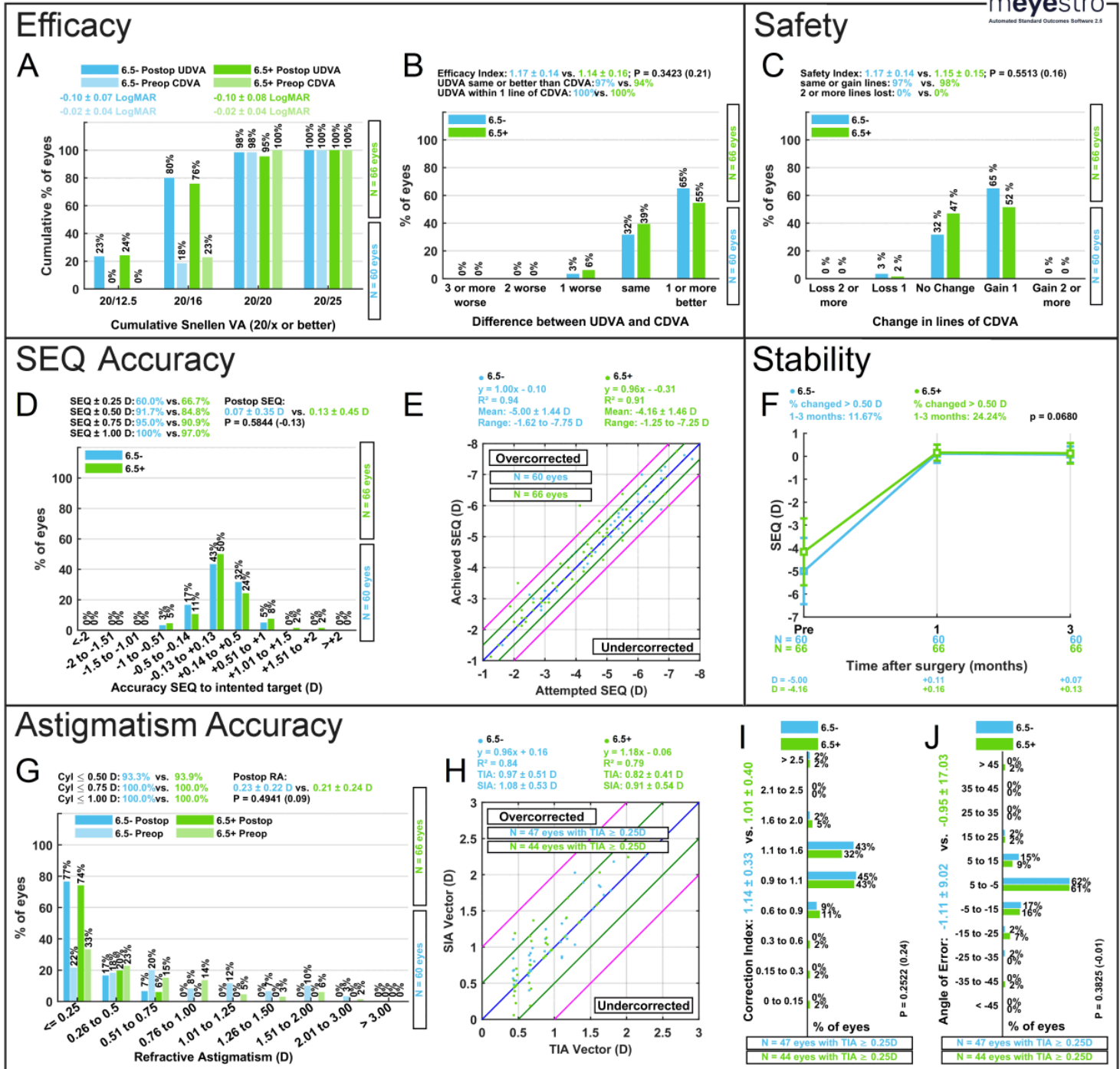
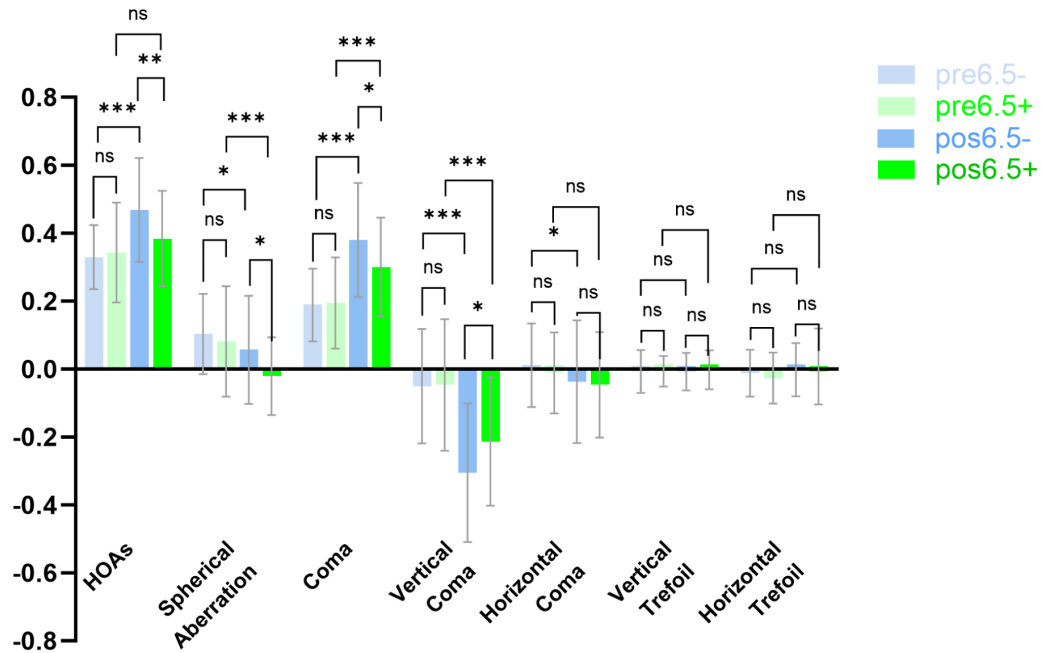


Figure 1

Visual and refractive outcomes following ray-tracing-guided FS-LASIK:(A) Cumulative Snellen UDVA and preoperative CDVA; (B) Difference between postoperative UDVA and preoperative CDVA; (C) Change in lines of CDVA; (D) Accuracy of SEQ relative to intended target; (E) Attempted vs. achieved SEQ; (F) Stability of SEQ over time; (G) Postoperative RA; (H) TIA vs. SIA; (I-J) CI and angle of error for astigmatic correction.

UDVA = Uncorrected Distance Visual Acuity; CDVA = Corrected Distance Visual Acuity; VA = Visual Acuity; SEQ = Spherical Equivalent; D = Diopters; RA = Refractive Astigmatism; TIA = Target-Induced Astigmatism; SIA = Surgically Induced Astigmatism; CI = Correction Index.

A



B

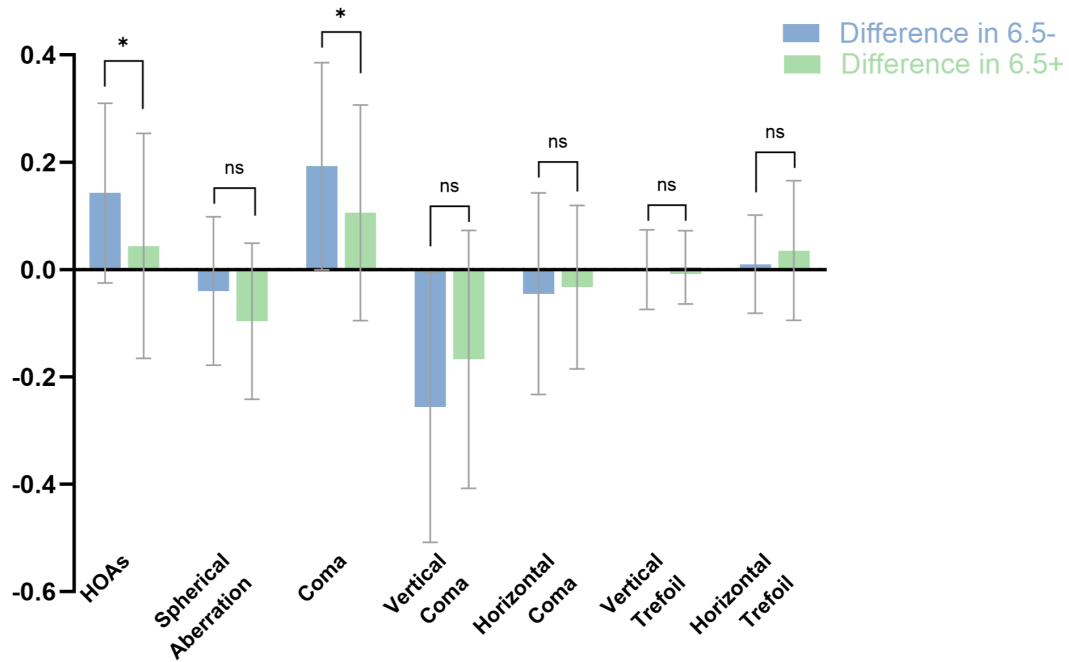


Figure 2

Total ocular wavefront aberrometry over a 6-mm analytical zone using the SightMap system. (A) Comparison of aberration parameters between the two groups before and 3 months after surgery; (B) Postoperative change in aberration values from the preoperative baseline for each group. Data are presented as mean $\pm$ SD.

HOAs = Higher Order Aberrations; * = P < 0.05; ** = P < 0.01; *** = P < 0.001; ns = Not Significant; SD = Standard Deviation.

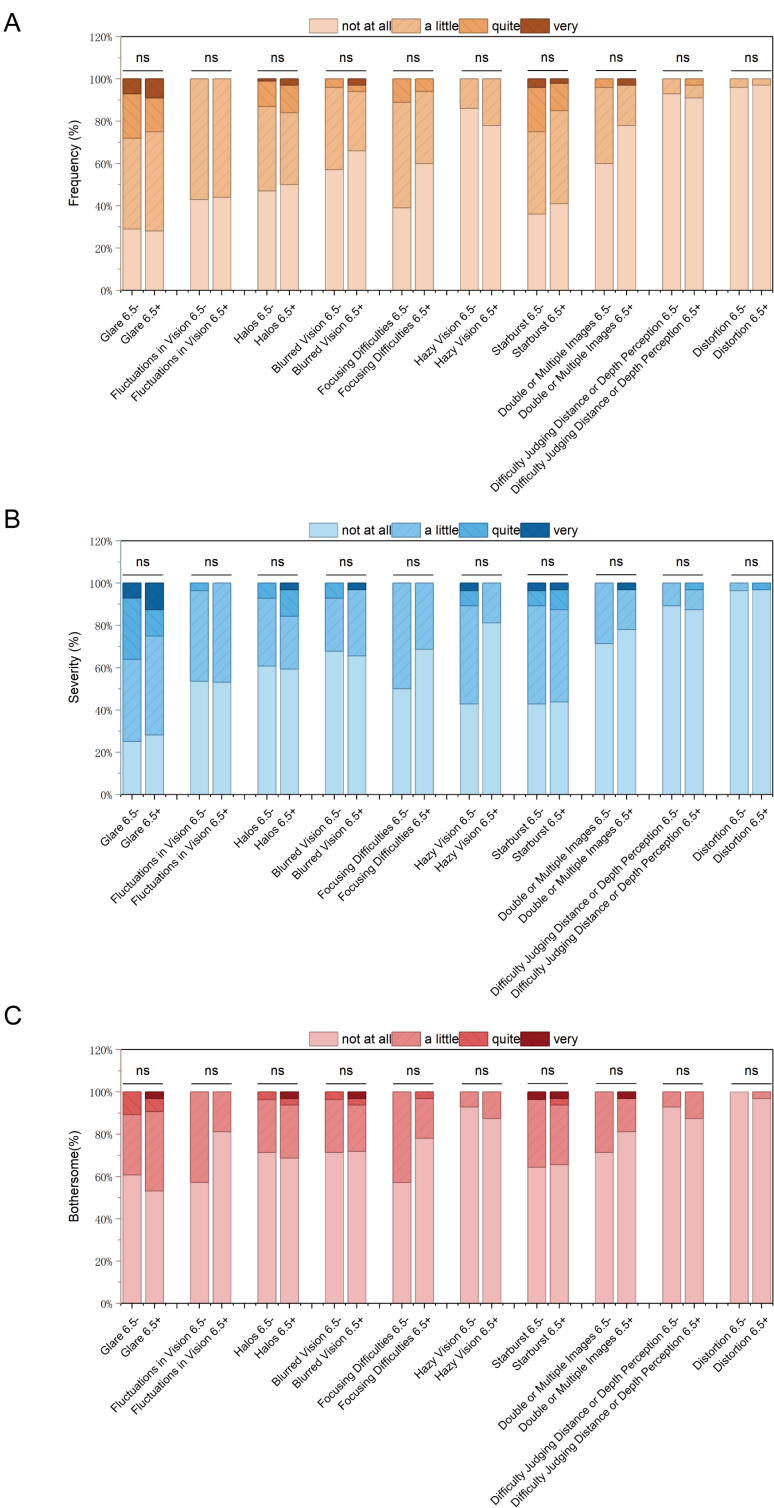


Figure 3

Patient-reported visual symptoms assessed by the Quality of Vision (QoV) questionnaire. (A) Frequency of symptoms (%); **(B)** Severity of symptoms (%); **(C)** Bothersome of symptoms (%).

ns = Not Significant.

Supplementary Files

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- [SupplementaryMaterial.docx](#)