Influencing Factors of Glare in Patients With Myopia After Small Incision Lenticule Extraction

Wuxiao Zhao, MD, PhD; Jifang Wang, PhD; Dan Fu, MD; Yangyi Huang, MD; Tian Han, MD; Xingtao Zhou, MD, PhD; Jing Zhao, MD, PhD

ABSTRACT

PURPOSE: To investigate influencing factors of glare in patients with myopia after small incision lenticule extraction (SMILE).

METHODS: Thirty patients (60 eyes) aged 24.9 ± 4.5 years with spherical equivalent of -6.69 ± 1.10 diopters (D) and astigmatism of -1.25 ± 0.76 D who underwent SMILE were consecutively recruited in this prospective study. Visual acuity, subjective refraction, Pentacam corneal topography (Oculus Optikgeräte GmbH), pupillometry, and glare test (Monpack One; Metrovision) were measured preoperatively and postoperatively. All patients were followed up for 6 months. The generalized estimation equation was used to judge the determinants of glare after SMILE, and a *P* value less than .05 was statistically significant.

RESULTS: Under mesopic conditions, the halo radii preoperatively and at 1, 3, and 6 months after SMILE were 207.72 ± 46.67, 216.17 ± 40.63, 200.67 ± 34.68, and 193.50 ± 40.75 minutes of arc (arcmin), respectively. Under photopic conditions, the glare radii were 79.10 ± 17.78, 87.00 ± 20.44, 78.00 ± 14.59, and 72.00 ± 15.27 arcmin, respectively. Compared with preoperative glare, no significant changes were detected in postoperative glare. However, glare at 6 months was statistically significantly improved compared to the values at 1 month (both $P < .05$). Under mesopic conditions, the main influencing factors of glare were sphere ($P = .007$), astigmatism ($P = .032$), uncorrected distance visual acuity (UDVA) ($P < .001$), and postoperative time (all $P < .05$). Under photopic conditions, the main influencing factors of glare were astigmatism, UDVA, and postoperative time (all $P < .05$).

CONCLUSIONS: Glare improved with time during the early stages after SMILE for myopia. Less glare was found to be associated with better UDVA, and greater residual astigmatism and sphere translated to more obvious glare.

[*J Refract Surg*. 2023;39(6):398-404.]

Light can be affected by small particles and irregular objects in the ocular medium, forming intraocular scattering light and thus reducing imaging contrast and prejudicing visual quality. This effect has been termed disability glare.[1] Intraocular scattering is mainly produced by the cornea among all eye components[2,3] under physiological conditions.[4,5] Under pathological status, corneal scattering is exacerbated due to increased opacity or irregularity.[6] For example, a transient increase of intraocular scattering can be observed after corneal refractive surgery[7,8] that could last for several months.[9]

From the Eye Institute and Department of Ophthalmology, Eye & ENT Hospital, Fudan University, Shanghai, China (WZ, JW, DF, YH, TH, XZ, JZ); NHC Key Laboratory of Myopia (Fudan University), Key Laboratory of Myopia, Chinese Academy of Medical Sciences, Shanghai, China (WZ, JW, DF, YH, TH, XZ, JZ); Shanghai Research Center of Ophthalmology and Optometry, Shanghai, China (WZ, JW, DF, YH, TH, XZ, JZ); and Center for Optometry and Visual Science, Guangxi Academy of Medical Sciences, The People's Hospital of Guangxi Zhuang Autonomous Region, Nanning, China (WZ).

Submitted: May 14, 2022; Accepted: May 5, 2023

Supported in part by the Project of Shanghai Science and Technology (Grant Nos. 20410710100 and 21Y11909800), Clinical Research Plan of SHDC (Grant No. SHDC2020CR1043B), and the Project of Shanghai Xuhui District Science and Technology (Grant No. XHLHGG202104), Shanghai Engineering Research Center of Laser and Autostereoscopic 3D for Vision Care (Grant No. 20DZ2255000), Construction of a 3D digital intelligent prevention and control platform for the whole life cycle of highly myopic patients in the Yangtze River Delta (Grant No. 21002411600).

Disclosure: The authors have no financial or proprietary interest in the materials presented herein.

Drs. Zhao and Wang contributed equally to this work and should be considered as equal first authors.

Correspondence: Xingtao Zhou, MD, PhD (doctzhouxingtao@163.com) and Jing Zhao, MD, PhD (zhaojing_med@163.com), Eye Institute and Department of Ophthalmology and Vision Science, Eye & ENT Hospital, Fudan University, 19 Baoqing Road, Shanghai 200031, China.

doi:10.3928/1081597X-20230505-01

Glare is an effect that can be measured objectively. In recent years, postoperative visual symptoms, especially factors related to glare after small incision lenticule extraction (SMILE), have attracted researchers' attention.[10-14] However, investigations concerning the interactions between refractive state, functional optical zone, pupil parameters, and glare after SMILE are still limited. In a previous study, we found that glare in the early stage after SMILE for myopia was related to the process of pupillary light reflex.[14] Building on this discovery, the current study investigated the potential influencing factors of glare in the early stages after SMILE for myopia.

PATIENTS AND METHODS

PATIENTS

This prospective study consecutively included 60 eyes of 30 patients with myopia and myopic astigmatism (5 men and 25 women) who underwent SMILE from May to July 2021 at the Eye, Ear, Nose, and Throat (Eye & ENT) Hospital of Fudan University. The average age was 24.9 ± 4.5 years (range: 18 to 35 years); the preoperative spherical equivalent (SE) was -6.69 ± 1.10 diopters (D) (range: -9.00 to -4.00 D). Detailed preoperative data are shown in **Table 1**. The inclusion criteria were as follows: patients with myopia or myopic astigmatism and corrected distance visual acuity of 20/20 or better; contact lens wearers ceased wearing soft contact lenses for at least 1 week, hard contact lenses for 1 month, and orthokeratology lenses for 3 months before surgery; the refractive state was stable (the annual change of myopia was 0.50 D or less); and the residual stromal bed thickness was greater than 280 µm. Patients with any conditions except for myopia were excluded. This study followed the tenets of the Declaration of Helsinki and the regulations of the ethics committee of the Eye & ENT Hospital of Fudan University. All patients signed informed consent before SMILE.

All patients underwent preoperative routine examinations, including slit-lamp biomicroscopy, uncorrected distance visual acuity (UDVA), intraocular pressure, axial length, central corneal thickness, corneal topography (Pentacam HR; Oculus Optikgeräte GmbH), cycloplegic refraction, funduscopy, pupillometry, and glare test (MonPack One; Metrovision). All examinations were completed by experienced technicians. At each follow-up time point, main measurements such as UDVA, subjective refraction, corneal topography, pupillometry, and glare tests were obtained for each patient.

TABLE 1
Preoperative Demographics and Refractive Data

Parameter	Mean ± SD	Range
Age, y	24.90 ± 4.50	18 to 35
Sex (M/F)	5/25 (16.67%/83.33%)	
Sphere, D	-6.07 ± 1.13	-8.25 to -3.00
Cylinder, D	-1.25 ± 0.76	-3.25 to 0.00
Spherical equivalent, D	-6.69 ± 1.10	-9.00 to -4.00
CDVA, logMAR	-0.02 ± 0.04	-0.10 to 0.00
Intraocular pressure, mm Hg	15.71 ± 2.15	10.30 to 20.70
Axial length, mm	26.26 ± 0.84	24.36 to 27.95
Central corneal thickness, µm	552.93 ± 24.40	503.00 to 602.00
Mesopic pupil diameter, mm	6.94 ± 0.53	5.40 to 8.10
Programmed optical zone, mm	6.66 ± 0.21	6.1 to 6.9
Lenticule thickness, µm	134.88 ± 12.91	102.00 to 150.00

CDVA = corrected distance visual acuity; D = diopters

PUPILLOMETRY

Pupillometry was similar to the protocols described by Zhao et al[15] using the MonPack One system with near-infrared illumination (880 nm) and high-resolution infrared camera. The system can automatically process the pupil images in real time, and the accuracy is 0.1 mm. After 15 minutes of dark adaptation, mesopic pupil diameters for both eyes were acquired simultaneously using the "static pupillometry" module (0.01 cd/m^2). Pupillary light reflex was induced by white flash (stimulation on-time 200 ms and off-time 3,300 ms, and total brightness 100 cd/m^2), in which valid responses could be recorded at least 10 times in 90 seconds.

This system can simultaneously record the bilateral pupillary light reflex and the output parameters, such as average response (initial pupil diameter, amplitude of contraction, contraction latency, duration of contraction, contraction speed, dilation latency, duration of dilation, and dilation speed) and temporal response (maximum, minimum, and average pupil diameters). Based on our previous results,[14,15] this study only extracts parameters such as the amplitude of contraction, dilation speed, and maximum, minimum, and average pupil diameters for further analysis.

GLARE TEST

Glare test results were consistent with our previous report.[15] LED white lights with a luminance of 200,000 cd/m^2 as the light-induced glare source are equipped with both sides of the vision monitor: the right eye is measured when the right light is briefly on and the left eye is measured when the left light is briefly on. At the moment of the glare test, the illuminance on the eye

was 7.502 lux. In this study, the luminance of the optotypes was set to 1 and 5 cd/m^2 sequentially. After 5 minutes of dark adaptation, the patient was required to read out each line of optotypes starting from the opposite of the light source. The unrecognized optotypes in each line were calculated in minutes of arc (arcmin), and the mean radius value was treated as disk halo size.

SMILE Procedure

As previously described,[11] all SMILE surgeries were performed by the same experienced surgeon (XZ) using a 500-kHz VisuMax platform (Carl Zeiss Meditec AG;). The cap thickness was set to 120 µm, cap diameter to 7.5 mm, and side cut length to 2 mm. The programmed optical zone was 6.7 ± 0.2 mm. The incision was made at the 12-o'clock position, and the lenticule was separated and extracted after the femtosecond laser scanning was completed.

A postoperative regimen including 0.5% levofloxacin eye drops (four times per day for 7 days), 0.1% fluorometholone eye drops (eight times per day, tapered over 24 days), and artificial tears (four times per day for 3 months) were routinely prescribed for all patients.

Follow-up times were scheduled postoperatively at 1 day, 1 week, and 1, 3, and 6 months.

Functional Optical Zone Assessment

Pentacam HR corneal topography was performed for all SMILE-treated eyes, and the total power distribution with image quality marked as "OK" was recorded. Because the corneal apex may change after SMILE, this study chose to calculate the keratometric readings in zones centered on the pupil center. The total refractive power value corresponding to the 4-mm zone in the keratometric value reading table was first identified. Then the maximum ring diameter that does not exceed 0.50 D of the total refractive power value obtained was used. This diameter was defined as the functional optical zone (FOZ) (**Figure A**, available in the online version of this article).[16] The FOZs of all SMILE-treated eyes at 1, 3, and 6 months postoperatively were acquired for further analysis.

Statistical Analysis

SPSS version 25 for Windows software (IBM Corporation) was used for statistical analysis. Quantitative data are expressed in mean ± standard deviation in this study. The variations of postoperative glare at each follow-up time point were compared by mixed linear models. The potential influencing factors such as residual refraction, UDVA, mesopic pupil diameter, FOZ, delta zone (the differences between the mesopic pupil diameter and FOZ at each time point were calculated and treated as delta zone), and pupillometry parameters on postoperative glare were explored by generalized estimation equation (GEE). A P value less than .05 was considered statistically significant.

RESULTS

All surgeries were uneventful, and vision-threatening complications such as epithelial injury, diffuse lamellar keratitis, and infection did not occur postoperatively. At the final visit, the mean efficacy index (postoperative UDVA/preoperative CDVA) was 1.19 ± 0.17, and the mean safety index (postoperative CDVA/preoperative CDVA) was 1.26 ± 0.18.

Refractive Outcomes

The standard six graphs for refractive outcomes in patients treated with SMILE are shown in **Figure B** (available in the online version of this article). All SMILE-treated eyes had a postoperative UDVA of 20/20 or better, and 85% of SMILE-treated eyes had a postoperative UDVA of 25/20 or better (**Figure BA**); 30% of eyes improved two or more lines of CDVA, 53% of eyes improved one line of CDVA, 15% of eyes were unchanged, one eye (2%) lost one line of CDVA, and no eyes lost two or more lines of CDVA (**Figure BB**). A scatter plot of the attempted versus achieved SE correction is shown in **Figure BC** (R^2 = 0.9411). The mean SE was 0.23 ± 0.27 D; 92% of the eyes were within ±0.50 D and 100% were within ±1.00 D (**Figure BD**). The mean residual astigmatism was -0.35 ± 0.23 D, 100% of the eyes were within ±0.50 D (**Figure BE**), and 7% of the eyes changed by more than 0.50 D between 1 and 6 months postoperatively (**Figure BF**).

Clinical Parameter Values

Table 2 summarizes the clinical parameter values at each follow-up time point. Among them, mesopic pupil diameter was measured by MonPack One and FOZ was extracted from corneal topography. When compared with the preoperative glare values, no significant changes were detected in postoperative glare, but a significant time effect on glare was noticed (mixed linear model; F = 3.031, 7.438; P = .032 and < .001, respectively). Glare at postoperative 6 months was significantly improved in contrast with that at 1 month under 1 cd/m^2 condition (P = .044), and glare at postoperative 3 and 6 months was also improved compared to postoperative 1 month under 5 cd/m^2 condition (P = .036 and < .001, respectively).

Univariate Correlation Analysis

Under high mesopic conditions (1 cd/m^2), UDVA, mesopic pupil diameter, delta zone, and minimum and average pupil diameters were positively correlat-

TABLE 2

Clinical Parameter Values at Different Follow-up Times After SMILE (Mean ± SD, N = 60)

Parameter	Preop	Postop 1 Month	Postop 3 Months	Postop 6 Months
Halo radius @ 1 cd/m^2, arcmin	207.72 ± 46.67	216.17 ± 40.63	200.67 ± 34.68	193.50 ± 40.75
Halo radius @ 5 cd/m^2, arcmin	79.10 ± 17.78	87.00 ± 20.44	78.00 ± 14.59	72.00 ± 15.27
Sphere, D	-6.07 ± 1.13	0.51 ± 0.21	0.46 ± 0.23	0.40 ± 0.29
Astigmatism, D	-1.25 ± 0.76	-0.30 ± 0.20	-0.30 ± 0.19	-0.35 ± 0.23
Spherical equivalent, D	-6.69 ± 1.10	0.36 ± 0.19	0.31 ± 0.24	0.23 ± 0.27
UDVA, logMAR	-0.02 ± 0.04	-0.09 ± 0.07	-0.12 ± 0.06	-0.11 ± 0.06
Functional optical zone, mm	–	4.92 ± 0.47	4.87 ± 0.41	4.83 ± 0.42
Mesopic pupil size, mm	6.96 ± 0.49	6.88 ± 0.51	6.78 ± 0.52	6.73 ± 0.59
Delta zone, mm	–	1.96 ± 0.64	1.95 ± 0.64	1.90 ± 0.71
Amplitude of contraction	1.85 ± 0.26	1.74 ± 0.25	1.68 ± 0.28	1.65 ± 0.29
Dilation speed, mm/s	2.04 ± 0.22	1.98 ± 0.27	1.93 ± 0.24	1.91 ± 0.24
Maximum pupil diameter, mm	5.66 ± 0.74	5.30 ± 0.57	5.21 ± 0.69	5.27 ± 0.84
Minimum pupil diameter, mm	3.07 ± 0.40	2.86 ± 0.37	2.78 ± 0.36	2.75 ± 0.38
Average pupil diameter, mm	4.49 ± 0.50	4.25 ± 0.47	4.14 ± 0.50	4.11 ± 0.58

arcmin = minutes of arc; D = diopters; preop = preoperative; postop = postoperative; SMILE = small incision lenticule extraction; UDVA = uncorrected distance visual acuity

ed with glare after SMILE, and postoperative follow-up time points and POZ were negatively correlated with glare after SMILE (all $P \leq .05$). However, no significant relationships were observed between the rest of the parameters and postoperative glare ($P > .05$).

Under low photopic conditions (5 cd/m^2), UDVA, mesopic pupil diameter, delta zone, maximum, minimum, and average pupil diameters, and amplitude of contraction were positively correlated with glare after SMILE, and postoperative follow-up time points were negatively correlated with glare after SMILE (all $P \leq .05$). However, no significant relationships were observed between the rest of the parameters and postoperative glare ($P > .05$, **Table 3**).

GEE Analysis

Under low photopic conditions (5 cd/m^2), the variables entering the regression equation of influencing factors of postoperative glare were postoperative astigmatism, UDVA, and postoperative follow-up time (both $P < .05$). The postoperative astigmatism and follow-up time were negatively correlated with glare, and UDVA was positively correlated with glare. Under high mesopic conditions (1 cd/m^2), the variables entering the regression equation of influencing factors of postoperative glare are postoperative astigmatism, sphere, UDVA, and postoperative follow-up time (all $P < .001$). The postoperative astigmatism, sphere, and follow-up time were negatively correlated with glare, and UDVA was positively correlated with glare (**Table 4**).

DISCUSSION

Glare and halo are common visual symptoms after refractive surgery.[17-20] Glare after myopic SMILE has also been reported, and often occurs in the early stage postoperative.[13,14] In terms of methodology, patient-reported outcomes are usually used for the evaluation of glare.[13,17-21] In this study, our team objectively measured the glare after SMILE for the first time and analyzed its influencing factors, which have certain clinical practical values in understanding postoperative glare.

High incidence of glare after corneal refractive surgery has been reported previously. For example, the incidence was 61.5% in PRK,[18] 27%[19] to 58.4%[20]in laser in situ keratomileusis (LASIK), and 54.4% in SMILE.[21] In this study, the glare after SMILE was objectively measured repeatedly. Although this objective result is not clinically impressive, it statistically decreased with time. Our recent study revealed that glare peaked at 1 week (a change of 225.43 to 260.57 arcmin for 1 cd/m^2 and 77.43 to 112.57 arcmin for 5 cd/m^2) and recovered at 3 months in patients with high myopia who were treated with SMILE (SE: -7.31 ± 0.89 D). However, in patients with low-to-moderate myopia (SE: -4.44 ± 1.41 D), the virtual glare effect was not observed postoperatively.[22] The current study showed a decreasing trend of glare after SMILE. The difference between them could be attributed to the first follow-up point (postoperative 1 week vs 1 month), which resulted in the virtual absence of glare effect in the current study. Additionally, this study aimed to explore the influencing factors of postoperative glare.

TABLE 3

Correlations Between Clinical Parameter Values and Disk Halo Size After SMILE

	Disk Halo Size @ 1 cd/m²			Disk Halo Size @ 5 cd/m²		
Parameter	**B Coefficient**	**95% CI**	***P***	**B Coefficient**	**95% CI**	***P***
Sphere	-12.484	-39.884 to 14.916	.372	8.228	-1.846 to 18.303	.109
Astigmatism	-21.372	-52.570 to 9.826	.179	-10.166	-20.847 to 0.515	.062
Spherical equivalent	-23.136	-52.433 to 6.161	.122	4.424	-7.362 to 16.210	.462
UDVA	256.222	171.047 to 341.397	< .001	121.001	82.012 to 159.990	< .001
Mesopic pupil diameter	20.034	10.119 to 29.949	< .001	10.117	4.619 to 15.615	< .001
POZ	-34.640	-61.497 to - 7.783	.011	-13.183	-29.148 to 2.783	.106
FOZ	12.440	-2.200 to 27.081	.096	8.695	1.785 to 15.605	.014
Delta zone	9.703	0.272 to 19.133	.044	3.904	0.033 to 7.775	.048
Amplitude of contraction	22.904	-0.016 to 45.825	.050	12.227	3.345 to 21.108	.007
Dilation speed	13.734	-3.573 to 31.041	.120	6.885	-4.012 to 17.781	.216
Maximum pupil diameter	5.404	-3.680 to 14.488	.244	3.648	0.738 to 6.559	.014
Minimum pupil diameter	25.015	8.397 to 41.632	.003	12.321	5.321 to 19.321	.001
Average pupil diameter	17.178	6.203 to 28.154	.002	8.751	3.765 to 13.736	.001
Time (1 = postop 1 month)	22.667	12.527 to 32.806	< .001	15.000	10.691 to 19.309	< .001
Time (2 = postop 3 months)	7.167	-1.643 to 15.977	.111	6.000	2.207 to 9.793	.002
Time (3 = postop 6 months)	0[a]					

Delta zone = mesopic pupil diameter – functional optical zone; FOZ = functional optical zone; postop = postoperative; POZ = programmed optical zone; SMILE = small incision lenticule extraction; UDVA = uncorrected distance visual acuity
[a]Unable to compute because time (3 = postop 6 months) was treated as internal control.

TABLE 4

Influencing Factors of Disk Halo Size After SMILE

Determinant	**B Coefficient**	**95% CI**	***P***
Halo size @1 cd/m²			
Sphere	-40.878	-70.657 to -11.100	.007
Astigmatism	-29.491	-56.498 to -2.484	.032
UDVA	214.174	122.861 to 305.487	< .001
Time (1 = postop 1 month)	20.661	8.050 to 33.271	.001
Time (2 = postop 3 months)	11.145	1.247 to 21.043	.027
Time (3 = postop 6 months)	0[a]		
Halo size @5 cd/m²			
Astigmatism	-9.793	-19.415 to - 0.171	.046
UDVA	95.199	57.782 to 132.616	< .001
Time (1 = postop 1 month)	12.222	8.209 to 16.235	< .001
Time (2 = postop 3 months)	7.120	2.793 to 11.447	.001
Time (3 = postop 6 months)	0[a]		

postop = postoperative; SMILE = small incision lenticule extraction; UDVA = uncorrected distance visual acuity
[a]Unable to compute because time (3 = postop 6 months) was treated as internal control.

Our results show that pupil-relevant variables including mesopic pupil, maximum, average, and minimum pupil diameter, delta zone, and contraction speed were positively correlated with postoperative glare (ie, the larger the pupil values, the greater the postoperative glare). In our experience, large pupil size might imply a large delta zone after SMILE treatment, and a large amplitude of contraction when

strong light stimuli hit the eye. During the glare test, one perceives light stimuli first, then pupil contraction follows. That could be the reason for our findings on glare. Our previous study based on patients with myopia has documented that the average pupil diameter was involved in affecting glare under photopic conditions[15] and dynamic pupil values (eg, maximum, minimum, and average pupil diameter) might be related to postoperative early-stage glare under photopic conditions.[14] However, this study is a full model analysis of glare after myopic SMILE, and GEE further screened out that pupil-relevant variables are not the main determinants of postoperative glare.

This study found that refraction status (sphere and astigmatism) affected the postoperative glare (ie, the higher the degree of residual refraction, the more obvious the postoperative glare). This suggests that attention should be paid to the accuracy of refraction in preoperative cycloplegic refraction, the correction of astigmatism in surgical design, improving the surgical skills of centration, or developing centration techniques to obtain better postoperative visual quality.[23,24]

In addition, this study also found that the postoperative glare was affected by postoperative time. With the extension of postoperative time, the glare will decrease. This trend was similar to the recently observed short-term increase of glare in the early stage after myopic SMILE,[22] and the glare of SMILE-treated eyes, in the long run, was comparable to that of unoperated eyes.[11]

The GEE results showed that pupil-relevant parameters such as mesopic pupil diameter, OZ, FOZ, and delta zone did not enter the regression equation. However, univariate correlation analysis showed that delta zone was positively correlated with postoperative glare. This suggests that for young patients with myopia, on the premise of ensuring the safety of the residual stromal bed thickness, programming a larger OZ to close the gap between mesopic pupil diameter and FOZ may reduce the postoperative glare.

A recent study reported that there was no correlation between mesopic pupil diameter, FOZ, delta zone, and glare after SMILE.[13] The methodology of the study, which used additional software to calculate FOZ and the glare scored by a subjective questionnaire, was different from the current study. The researchers explained that the above results may be due to the use of auxiliary lighting equipment at night. Similarly, the traditional view that mesopic pupil diameter predicts the risk of glare or halo after LASIK has not been confirmed.[25] Schallhorn et al[26] claimed that mesopic pupil diameter could not be used as a predictor of postoperative satisfaction or visual symptoms of patients treated with wavefront-guided LASIK. The above results together with our findings revealed the basic fact of postoperative glare: the effect of mesopic pupil size on postoperative glare may be clinically overestimated.

Our results showed that postoperative UDVA was related to its glare (ie, less glare was found to be associated with better UDVA). A large-sample retrospective study by Schallhorn et al[26] found that glare was closely related to UDVA 1 month after LASIK, and patients with poor UDVA were more likely to complain about visual dissatisfaction at night. Another prospective study also observed that glare was associated with UDVA at 3 months after LASIK.[27] These results were consistent with the results of the current study.

The limitations of this study mainly arise from our small sample size. Hence, monocular inclusion was not used for statistical analysis. Our results also found delta zone to be associated with postoperative glare. However, there are some algorithm approaches for FOZ from which delta zone is derived.[13,16,28,29] Overall, our results should be verified by larger sample sizes and scrutiny of the various methods for assessing FOZ.

Glare improved with time during the early stages after myopic SMILE. Less glare was found to be associated with better UDVA, and greater residual astigmatism and sphere translated to more obvious glare.

AUTHOR CONTRIBUTIONS

Study concept and design (WZ, JW, XZ, JZ), data collection (WZ, DF, YH), analysis and interpretation of data (WZ, JW, DF, YH, TH, XZ, JZ), writing the manuscript (WZ, JW, TH, JZ), critical revision of the manuscript (WZ, JW, DF, YH, TH, XZ, JZ), supervision (XZ)

REFERENCES

1. van den Berg TJ. On the relation between glare and straylight. *Doc Ophthalmol*. 1991;78(3-4):177-181. https://doi.org/10.1007/BF00165678 PMID:1790738
2. Yuan R, Yager D, Guethlein M, Oliver G, Kapoor N, Zhong R. Controlling unwanted sources of threshold change in disability glare studies: a prototype apparatus and procedure. *Optom Vis Sci*. 1993;70(11):976-981. https://doi.org/10.1097/00006324-199311000-00016 PMID:8302535
3. Aslam TM, Haider D, Murray IJ. Principles of disability glare measurement: an ophthalmological perspective. *Acta Ophthalmol Scand*. 2007;85(4):354-360. https://doi.org/10.1111/j.1600-0420.2006.00860.x PMID:17313443
4. van den Berg TJ. Analysis of intraocular straylight, especially in relation to age. *Optom Vis Sci*. 1995;72(2):52-59. https://doi.org/10.1097/00006324-199502000-00003 PMID:7753528
5. Van Den Berg TJ, Van Rijn LJ, Michael R, et al. Straylight effects with aging and lens extraction. *Am J Ophthalmol*. 2007;144(3):358-363. https://doi.org/10.1016/j.ajo.2007.05.037 PMID:17651678

6. van den Berg TJ, Hwan BS, Delleman JW. The intraocular straylight function in some hereditary corneal dystrophies. *Doc Ophthalmol*. 1993;85(1):13-19. https://doi.org/10.1007/BF01268096 PMID:8181422

7. Wan KH, Tsui RWY, Chan TCY. Fluctuation in straylight measurements during the visual recovery phase after small incision lenticule extraction. *Eye (Lond)*. 2020;34(2):366-373. https://doi.org/10.1038/s41433-019-0552-6 PMID:31399702

8. Beerthuizen JJ, Franssen L, Landesz M, van den Berg TJ. Straylight values 1 month after laser in situ keratomileusis and photorefractive keratectomy. *J Cataract Refract Surg*. 2007;33(5):779-783. https://doi.org/10.1016/j.jcrs.2007.01.017 PMID:17466847

9. Barreto J Jr, Barboni MT, Feitosa-Santana C, et al. Intraocular straylight and contrast sensitivity after contralateral wavefront-guided LASIK and wavefront-guided PRK for myopia. *J Refract Surg*. 2010;26(8):588-593. https://doi.org/10.3928/1081597X-20090930-01 PMID:19810663

10. Gyldenkerne A, Ivarsen A, Hjortdal J. Optical and visual quality after small-incision lenticule extraction. *J Cataract Refract Surg*. 2019;45(1):54-61. https://doi.org/10.1016/j.jcrs.2018.08.026 PMID:30391154

11. Zhao W, Han T, Li M, Sekundo W, Aruma A, Zhou X. Nighttime symptoms after monocular SMILE: a contralateral eye study. *Ophthalmol Ther*. 2021;10(4):1033-1044. https://doi.org/10.1007/s40123-021-00396-5 PMID:34559401

12. Schmelter V, Dirisamer M, Siedlecki J, et al. Determinants of subjective patient-reported quality of vision after small-incision lenticule extraction. *J Cataract Refract Surg*. 2019;45(11):1575-1583. https://doi.org/10.1016/j.jcrs.2019.06.012 PMID:31585852

13. Li M, Zhang L, Song Y, et al. Effect of wavefront aberrations on night vision problems and mesopic contrast threshold after SMILE. *J Refract Surg*. 2021;37(7):446-452. https://doi.org/10.3928/1081597X-20210405-02 PMID:34236902

14. Han T, Zhao F, Chen X, Miao H, Chen Z, Zhou X. Evaluation of disk halo size after small incision lenticule extraction (SMILE). *Graefes Arch Clin Exp Ophthalmol*. 2019;257(12):2789-2793. https://doi.org/10.1007/s00417-019-04481-1 PMID:31664518

15. Zhao W, Zhao J, Han T, Li M, Wang J, Zhou X. Evaluation of disk halo size and identification of correlated factors in myopic adults. *Front Med (Lausanne)*. 2022;9:743543. https://doi.org/10.3389/fmed.2022.743543 PMID:35155490

16. Tabernero J, Klyce SD, Sarver EJ, Artal P. Functional optical zone of the cornea. *Invest Ophthalmol Vis Sci*. 2007;48(3):1053-1060. https://doi.org/10.1167/iovs.06-0867 PMID:17325146

17. Schallhorn SC, Venter JA, Hannan SJ, Hettinger KA, Teenan D. Effect of postoperative keratometry on quality of vision in the postoperative period after myopic wavefront-guided laser in situ keratomileusis. *J Cataract Refract Surg*. 2015;41(12):2715-2723. https://doi.org/10.1016/j.jcrs.2015.06.034 PMID:26796452

18. Brunette I, Gresset J, Boivin JF, et al. Functional outcome and satisfaction after photorefractive keratectomy. Part 2: survey of 690 patients. *Ophthalmology*. 2000;107(9):1790-1796. https://doi.org/10.1016/S0161-6420(00)00267-0 PMID:10964847

19. Bailey MD, Mitchell GL, Dhaliwal DK, Boxer Wachler BS, Zadnik K. Patient satisfaction and visual symptoms after laser in situ keratomileusis. *Ophthalmology*. 2003;110(7):1371-1378. https://doi.org/10.1016/S0161-6420(03)00455-X PMID:12867394

20. 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*. 2005;31(10):1943-1951. https://doi.org/10.1016/j.jcrs.2005.08.022 PMID:16338565

21. Wei R, Li M, Zhang H, et al. Comparison of objective and subjective visual quality early after implantable collamer lens V4c (ICL V4c) and small incision lenticule extraction (SMILE) for high myopia correction. *Acta Ophthalmol*. 2020;98(8):e943-e950. https://doi.org/10.1111/aos.14459 PMID:32419383

22. Zhao W, Zhao J, Zhang Z, Han T, Wang J, Zhou X. Evaluating early-stage disk halo changes after small incision lenticule extraction. *Eur J Ophthalmol*. 2022;11206721221138306:11206721221138306. https://doi.org/10.1177/11206721221138306 PMID:36377271

23. Alió Del Barrio JL, Vargas V, Al-Shymali O, Alió JL. Small incision lenticule extraction (SMILE) in the correction of myopic astigmatism: outcomes and limitations: an update. *Eye Vis (Lond)*. 2017;4(1):26. https://doi.org/10.1186/s40662-017-0091-9 PMID:29167808

24. Köse B. Detection of and compensation for static cyclotorsion with an image-guided system in SMILE. *J Refract Surg*. 2020;36(3):142-149. https://doi.org/10.3928/1081597X-20200210-01 PMID:32159818

25. Myung D, Schallhorn S, Manche EE. Pupil size and LASIK: a review. *J Refract Surg*. 2013;29(11):734-741. https://doi.org/10.3928/1081597X-20131021-02 PMID:24203804

26. Schallhorn S, Brown M, Venter J, Hettinger K, Hannan S. The role of the mesopic pupil on patient-reported outcomes in young patients with myopia 1 month after wavefront-guided LASIK. *J Refract Surg*. 2014;30(3):159-165. https://doi.org/10.3928/1081597X-20140217-02 PMID:24763720

27. Schallhorn SC, Kaupp SE, Tanzer DJ, Tidwell J, Laurent J, Bourque LB. Pupil size and quality of vision after LASIK. *Ophthalmology*. 2003;110(8):1606-1614. https://doi.org/10.1016/S0161-6420(03)00494-9 PMID:12917181

28. Damgaard IB, Ang M, Mahmoud AM, Farook M, Roberts CJ, Mehta JS. Functional optical zone and centration following SMILE and LASIK: a prospective, randomized, contralateral eye study. *J Refract Surg*. 2019;35(4):230-237. https://doi.org/10.3928/1081597X-20190313-01 PMID:30984980

29. Huang Y, Ding X, Han T, Fu D, Yu Z, Zhou X. Effective optical zone following small incision lenticule extraction for myopia calculated with two novel methods. *J Refract Surg*. 2022;38(7):414-421. https://doi.org/10.3928/1081597X-20220608-02 PMID:35858198

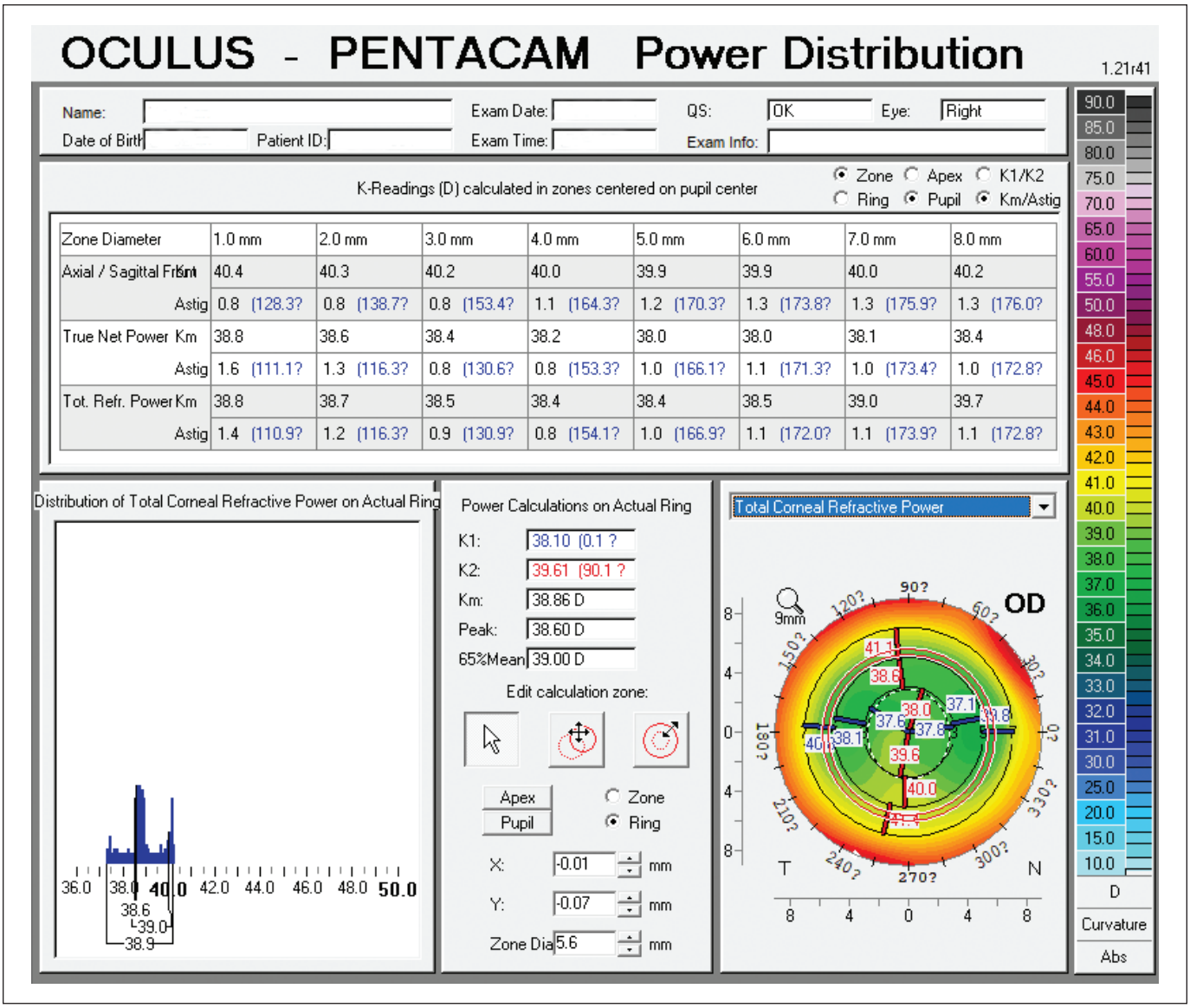

Figure A. Evaluation of the functional optical zone (FOZ) after myopic small incision lenticule extraction. Based on the mean value of corneal total refractive power in the 4-mm pupil center (mean keratometry [Km] was 38.40 diopters [D] in this case), the "zone diameter" (5.6 mm) that does not exceed 0.50 D of the Km value obtained was treated as FOZ.

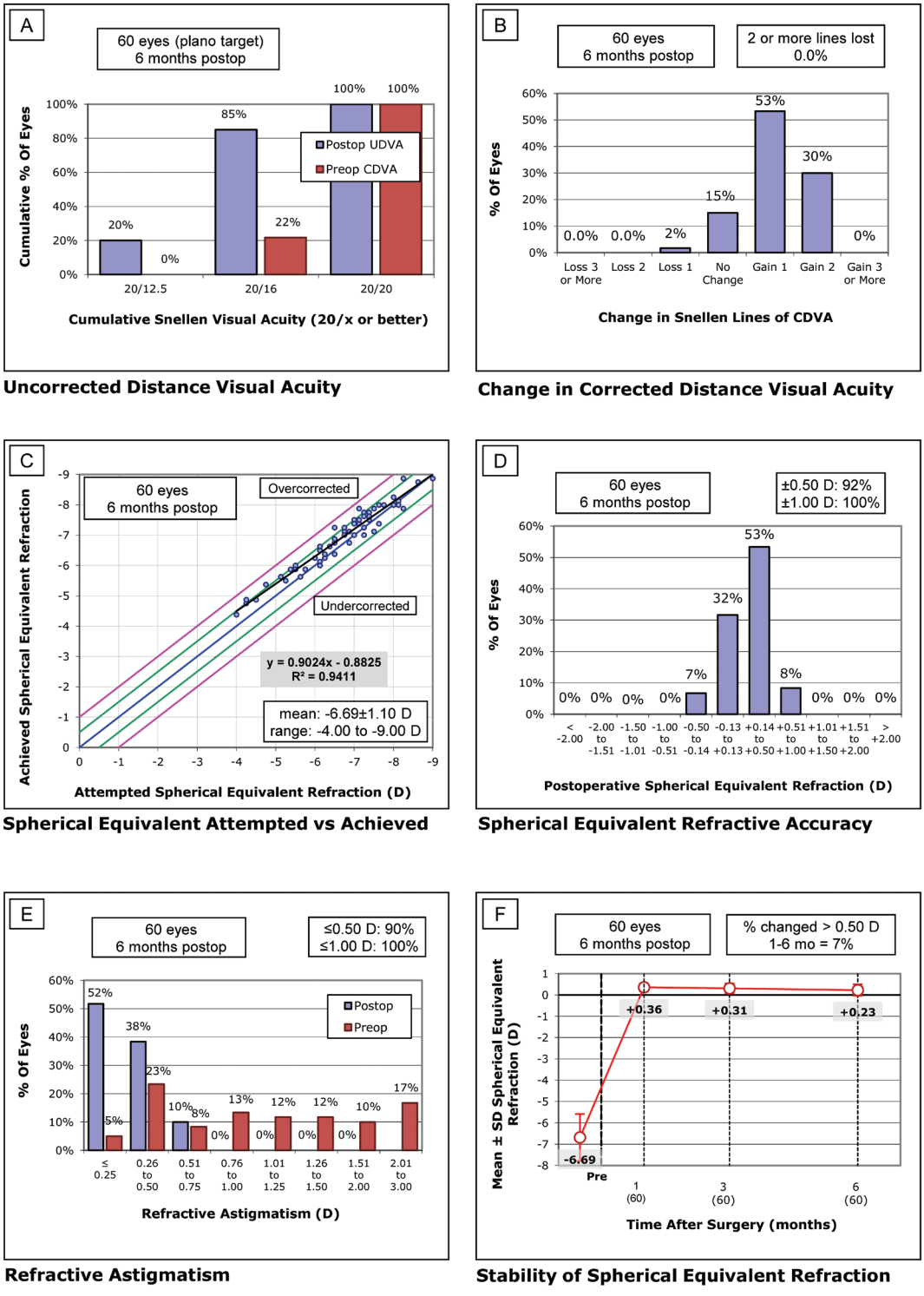

Figure B. Standard refractive outcomes at 6 months in patients treated with small incision lenticule extraction. (A) Uncorrected distance visual acuity. (B) Change in corrected distance visual acuity. (C) Attempted versus achieved spherical equivalent. (D) Spherical equivalent refractive accuracy. (E) Refractive astigmatism. (F) Stability of spherical equivalent refraction. D = diopters