Early Clinical Outcomes of Wavefront-Guided Myopic LASIK Treatments Using a New-Generation Hartmann-Shack Aberrometer

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ABSTRACT

PURPOSE: To provide an initial retrospective evaluation of early postoperative outcomes after wavefront-guided myopic LASIK using a new-generation Hartmann-Shack wavefront sensor.

METHODS: A noncomparative, retrospective study of 243 eyes of 126 patients that underwent primary wavefront-guided LASIK, using wavefront data obtained with a new Hartmann-Shack aberrometer (iDesign Advanced WaveScan aberrometer; Abbott Medical Optics, Inc., Santa Ana, CA). Visual acuity, refraction, and patient satisfaction were evaluated 1 month after surgery.

RESULTS: The manifest spherical equivalent was reduced from -3.28 ± 1.79 diopters (D) (range: -9.88 to -0.38 D) before surgery to -0.03 ± 0.29 D (range: -1.00 to +1.25 D) 1 month after surgery. The manifest spherical equivalent was within 0.50 and 1.00 D of target in 93.0% and 99.6% of eyes, respectively. Manifest astigmatism preoperatively (-0.72 ± 0.67 [range: 0.0 to -5.00 D]) was reduced to -0.14 ± 0.20 (range: 0.0 to -1.00 D) at 1 month and the vector-derived correction ratio (surgically induced refractive change/intended refractive correction) was 1.02 ± 0.30. Uncorrected distance visual acuity of 20/16, 20/20, and 20/25 or better was achieved in 79.0%, 93.4%, and 96.7% of eyes, respectively. No eyes lost two or more lines of corrected distance visual acuity, whereas a gain of one or more lines was observed in 14.0%. Most patients (98.5%) reported that they were satisfied with the outcome of their procedure.

CONCLUSIONS: Wavefront-guided LASIK using the new aberrometer in this retrospective evaluation was effective, safe, and predictable in the early postoperative time period for the correction of myopia with high patient satisfaction.

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S everal technologic advances have improved the precision of wavefront-guided procedures, such as the development of more precise aberrometers for characterizing ocular aberrations and better registration between the aberrometer derived ablation profile and the eye under the excimer laser, typically using iris registration.[1] Technology that employs iris registration improves wavefront-guided laser treatments by using a static reference point for centration, the iris periphery, instead of the pupillary center that may change significantly with illumination conditions.[1] Relying on the variable pupil center as a reference point for a wavefront-guided treatment can lead to an inappropriate centration of the ablation and consequently visual degradation with the corresponding night vision disturbances.[2]

There have also been improvements in the accuracy and resolution of wavefront sensors that link to excimer laser systems, such as the increase in the sampling capability and the use of different mathematical approaches for wavefront data reconstruction.[3] One example is the new Hartmann-Shack aberrometer (iDesign Advanced WaveScan aberrometer; Abbott Medical Optics, Inc., Santa Ana, CA), which captures more data points than previous sensors, averaging 1,250 data points from a 7.0-mm pupil, and analyzes the aberration data obtained using Fourier reconstruction. The new aberrometer is Conformity Europe approved for use in Europe. To our knowledge, this is the first report of clinical outcomes using this wavefront sensing technology to create the ablation profile for LASIK treatments. The aim of the current study is to report visual and refractive outcomes and patient satisfaction after wavefront-guided LASIK for the correction of myopia using this new-generation Hartmann-Shack wavefront sensor.

PATIENTS AND METHODS

PATIENTS

This study was deemed exempt from full review by the Committee on Human Research at the University of California, San Francisco, because it used only de-identified patient data. All patients gave their informed consent to undergo the LASIK procedure.

All records for LASIK procedures from one single center without patient identifiers were extracted from the Optical Express electronic medical record system using the following criteria: (1) primary LASIK procedure performed with the VISX STAR S4 IR excimer laser (Abbott Medical Optics, Inc.) using a wavefront-guided ablation profile (Advanced CustomVue; Abbott Medical Optics, Inc.) derived from a novel aberrometer (iDesign) between May and September 2012, (2) refractive target was emmetropia, and (3) no prior refractive procedures. Data extraction techniques have been previously described.[4]

Corneal flaps were created with either a femtosecond laser (IntraLase iFS; Abbott Medical Optics, Inc.) or a mechanical microkeratome (Moria Evo3 One Use-Plus microkeratome; Moria SA, Antony, France). Patient preference determined the method of flap creation.

Patient treatment criteria consisted of a myopic manifest spherical equivalent up to -10.0 with no more than 6.0 diopters (D) of refractive astigmatism, corrected distance visual acuity (CDVA) of 20/32 or better in both eyes, and patient age of at least 18 years. Exclusion criteria for treatment were concurrent medications or medical conditions that could impair healing, active ophthalmic disease, abnormal corneal shape in either eye, corneal thickness insufficient to allow the residual remaining stromal bed to be at least 250 µm in each eye, and central corneal thickness of less than 480 µm. Soft contact lens wearers were asked to discontinue use at least 1 week prior to the procedure. Hard contact lens users (polymethylmethacrylate or rigid gas permeable lenses) removed their lenses at least 3 weeks prior to baseline measurements and had two central keratometry readings and two manifest refractions taken at least 1 week apart that did not differ by more than 0.50 D in either meridian.

EXAMINATION PROTOCOL

All patients underwent a complete preoperative examination and the results were recorded immediately into an electronic medical record. This included manifest and cycloplegic refraction, monocular and binocular uncorrected distance visual acuity (UDVA), CDVA testing using a calibrated projected eye chart, low-light pupil diameter, slit-lamp biomicroscopy, applanation tonometry, corneal topography, ultrasound pachymetry, and wavefront-aberration measurement.

TABLE 1

Questionnaire From the Joint LASIK Study Task Force[a]

Questions	Responses
How satisfied are you with the outcome of your refractive procedure?	
Very satisfied	79.8%
Satisfied	18.8%
Neither satisfied nor dissatisfied	1.6%
Dissatisfied	0%
Very dissatisfied	0%
Has your overall vision turned out to be:	
Much better than expected	68.0%
Better than expected	15.6%
About what I expected	14.8%
Worse than expected	1.6%
Much worse than expected	0%
Thinking about your vision during the last week, if you had to do it over, would you have laser vision correction surgery again?	
Yes	96.9%
No	3.1%
Would you recommend laser vision correction surgery to your friends and relatives?	
Yes	100%
No	0%

[a]The questionnaire was used to assess procedure satisfaction and expectations in the current study. The results of the questionnaire were obtained in the analyzed sample 1 month after LASIK (n = 67).

Patients were examined the day after surgery and then during follow-up visits at 1 week and 1 month after the procedure. On the first postoperative day, a detailed slit-lamp examination was performed to evaluate flap position and integrity of the cornea. At the remaining postoperative visits, the same examination techniques as preoperatively were used (excluding cycloplegic refraction, pupil diameter, topography, and pachymetry). As part of our current practice, all patients were asked to complete a questionnaire during their 1-month postoperative examination (**Table 1**). It was self-administered by the patient using a password protected and secure computer terminal in an isolated area of the clinic. The questionnaire responses were stored in the secured Optical Express central database, which is compliant with ISO 27001 for information security management systems. The data were only accessible to biostatistics personnel. The questionnaire was derived from the Joint LASIK Study Task Force and assessed procedure satisfaction and expectations as listed in **Table 1**.[5] All

TABLE 2
Nomogram for Physician Adjustment Based on Preoperative Cylinder Values Obtained With the Aberrometer

Preoperative Cylinder on Aberrometry (D) (Range)	Physician Adjustment for Sphere (D)
0.00 to 0.25	-0.25
0.26 to 0.75	-0.13
0.76 to 1.00	0.00
1.01 to 2.00	0.20
2.01 to 3.00	0.40
3.01 to 4.00	0.60
4.01 to 5.00	0.80
5.01 to 6.00	1.00
6.01 to 7.00	1.20
7.01 to 8.00	1.40

D = diopters

response fields used a Likert scale to obtain the patient's preferences or degree of agreement.

WAVEFRONT MEASUREMENT AND ABLATION PROFILE

Ocular aberrations were captured with the iDesign aberrometer. This device is a Hartmann-Shack wavefront sensor based on the WaveScan system, but has a higher quantity and density of lenslets and a higher dynamic range. The system also performs several other simultaneous measurements: topography, autorefractometry, pupillometry, and keratometry. The new aberrometer has a capability of providing a measurement of ocular aberrations by analyzing up to 1,257 data points for a 7.0-mm pupil. It has a dynamic range of -16.00 to +12.00 D of sphere, 0.00 to 8.00 D of cylinder, and up to 8 µm of higher-order aberrations root mean square. Data reconstruction was performed using a Fourier algorithm, equivalent in resolution to a 20th order Zernike analysis. This reconstruction uses all valid data within the pupil aperture even for noncircular or irregular shaped pupils.

The ablation algorithm was derived from all aberrations, lower and higher order, as measured by the aberrometer. For all treatments, the optical zone diameter was 6.0 mm with a transition zone of 8.00 mm. For patients with astigmatism, 6.00 mm was the size of the minor axis of the elliptical ablation.

A nomogram was used that adjusted the sphere according to the magnitude of the aberrometer-derived cylinder (**Table 2**). This nomogram was developed from previous studies of LASIK using the same aberrometer and intended to reduce apparent sphere overcorrection associated with correcting high cylinder.

SURGERY

All LASIK procedures were performed by experienced surgeons certified to use the equipment. After patient positioning and ablation profile confirmation by the surgeon, a corneal flap was created by either a femtosecond laser (iFS; Abbott Medical Optics, Inc.) or a mechanical microkeratome (Moria Evo3 One Use-Plus microkeratome; Moria SA). The diameter of the femtosecond flaps ranged from 8.00 to 9.20 mm, and the programmed depth ranged from 100 to 120 µm. The 130-µm head was used for the mechanical microkeratome. After the flaps were lifted, the programmed treatment was applied to the exposed stroma after iris registration was achieved. All surgical procedures were performed under topical anesthesia. Standard topical postoperative treatment was administered to all patients, consisting of a topical antibiotic, steroid, and preservative-free artificial tear drops.

STATISTICAL ANALYSIS

Data analysis was performed using SPSS software version 19.0 (SPSS, Inc., Chicago, IL) for Windows (Microsoft Corporation, Redmond, WA). Normality of data samples was evaluated by means of the Kolmogorov–Smirnov test. When parametric analysis was possible, the Student's *t* test for paired data was used for comparisons between the preoperative and postoperative data and between postoperative data from consecutive visits, whereas the Wilcoxon rank sum test was applied to assess the significance of such differences when parametric analysis was not possible. Correlation coefficients (Pearson or Spearman depending if normality condition could be assumed) were used to assess the correlation between different variables. For the analysis of astigmatic changes, an additional vector analysis was performed following previously established guidelines.[6,7]

RESULTS

The first 243 consecutive eyes of 126 patients that underwent primary myopic LASIK using the new aberrometer were included in this study. All patients attended their 1-month postoperative examination. The mean patient age was 34.5 ± 10.1 years (range: 18 to 63 years). Seventy-two patients (57.1%) were male and 54 were female (42.9%). Mean preoperative corneal thickness was 552.7 ± 33.1 µm (range: 489 to 639 µm). Mean preoperative keratometry was 43.57 ± 1.56 D (range: 39.63 to 49.00 D). The mesopic pupil size of patients ranged from 4.5 to 8.5 mm, with a mean value of 6.7 ± 0.9 mm. The minor axis of the optical zone was 6.0 mm and the mean major axis (elliptical ablations for cylinder correction) was 6.29 mm (standard deviation: 0.30; range: 6.00 to 6.70 mm).

TABLE 3

Preoperative and Postoperative Visual and Refractive Outcomes

Parameter	Preoperative		1 Week Postoperative		1 Month Postoperative		P (Preoperative to 1 month)
	Mean (SD)	Median (Range)	Mean (SD)	Median (Range)	Mean (SD)	Median (Range)	
logMAR monocular UDVA	0.92 (0.36)	1.00 (-0.10 to 1.30)	-0.06 (0.09)	-0.10 (-0.20 to 0.34)	-0.08 (0.08)	-0.10 (-0.20 to 0.34)	< .01
Manifest sphere (D)	-2.92 (1.79)	-2.75 (-8.75 to -0.25)	-0.03 (0.30)	0.00 (-1.00 to +1.00)	+0.04 (0.30)	0.00 (-0.75 to +1.25)	< .01
Manifest cylinder (D)	-0.72 (0.67)	-0.50 (-5.00 to 0.00)	-0.12 (0.18)	0.00 (-0.75 to 0.00)	-0.14 (0.20)	0.00 (-1.00 to 0.00)	< .01
Manifest SE (D)	-3.28 (1.79)	-3.00 (-9.88 to -0.38)	-0.09 (0.31)	0.00 (-1.00 to +1.00)	-0.03 (0.29)	0.00 (-1.00 to +1.25)	< .01
logMAR CDVA	-0.09 (0.05)	-0.10 (-0.20 to 0.18)	-0.09 (0.06)	-0.10 (-0.20 to 0.18)	-0.10 (0.05)	-0.10 (-0.20 to 0.20)	< .01

SD = standard deviation; UDVA = uncorrected distance visual acuity; D = diopters; SE = spherical equivalent; CDVA = corrected distance visual acuity
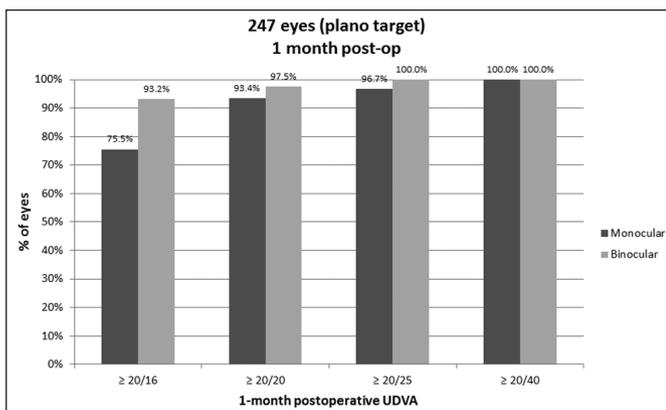
Figure 1. Distribution of 1-month postoperative logMAR monocular and binocular uncorrected distance visual acuity (UDVA) in the evaluated sample.

Figure 2. Distribution of changes in postoperative corrected distance visual acuity (CDVA) at 1 month postoperatively.

VISUAL OUTCOMES

Significant improvements in both UDVA (Wilcoxon test, $P < .01$) and CDVA (Wilcoxon test, $P \leq .04$) were observed postoperatively (**Table 3**). The percent of eyes that achieved 20/16, 20/20, and 20/25 monocular UDVA was 75.5% (186 eyes), 93.4% (227 eyes), and 96.7% (235 eyes), respectively (**Figure 1**). In those patients who had both eyes treated (n = 118), the percent of eyes that achieved 20/16, 20/20, and 20/25 binocular UDVA was 93.2% (110 patients), 97.5% (115 patients), and 100% (118 patients), respectively (**Figure 1**). There were no eyes that lost two or more lines of CDVA (**Figure 2**). A gain of one or more lines of CDVA was observed in 14.0% (34 eyes) of eyes of the overall sample (**Figure 2**).

REFRACTIVE OUTCOMES

There was a significant reduction in the manifest refraction (Wilcoxon test, $P < .01$) (**Table 3**). At 1 month postoperatively, the manifest spherical equivalent was within 1.0 D of emmetropia in 242 eyes (99.6%) and within 0.50 D in 226 eyes (93.0%). **Figure 3** shows the achieved spherical equivalent correction plotted at 1 month postoperatively against the intended. A robust and statistically significant correlation was found among the achieved and the intended correction (r = 0.99, $P < .01$). **Figure 4** displays the distribution of the preoperative and postoperative refractive cylinder in a double angle plot, showing a significant postoperative reduction in cylinder.

Table 4 summarizes the outcomes of the vector analysis of the refractive astigmatism changes. A weak but statistically significant correlation was found between the magnitudes of surgically induced refractive correction (SIRC) and error vector (r = 0.28, $P < .01$). **Figure 5** displays the magnitude of the SIRC as a function of the intended refractive change (IRC). A strong and statistically significant correlation was found among the
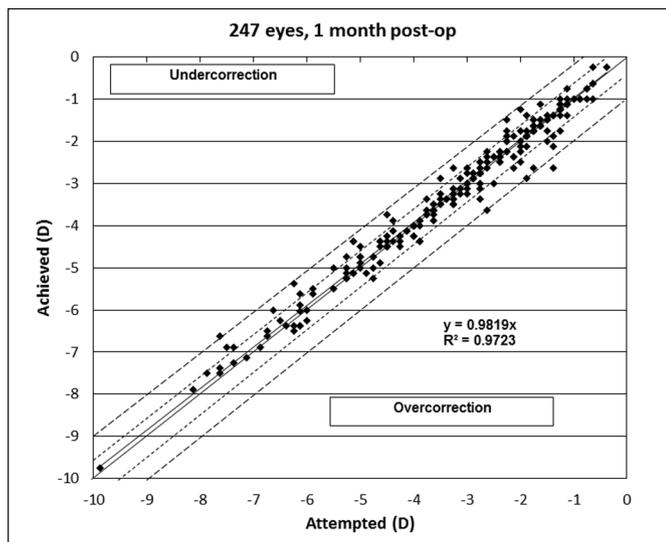
Figure 3. Scattergram showing the relationship between the achieved postoperative spherical equivalent correction at 1 month postoperatively and the intended.

magnitude of SIRC and IRC vectors (r = 0.95, P < .01). No statistically significant differences were found between the magnitude of SIRC and IRC vectors (Wilcoxon test, P = .27). A total of 90.1% (219 eyes) of eyes showed an error of angle of 5° or less.

SUBJECTIVE QUESTIONNAIRE OUTCOMES

The questionnaire was completed in 67 patients (53.2% completion rate). Most patients, (66 of 67, 98.5%) reported being satisfied or satisfied with the outcome of their procedure (**Table 1**). All patients would recommend the procedure to a friend or relative (100.0%) and, if they had to do it over, almost all patients would have the surgery again (97.0%, 65 patients). All patients indicated that their vision met or exceeded their expectations (100%).

DISCUSSION

In this study, wavefront-guided LASIK using a novel aberrometer to derive the treatment profile, safety, refractive predictability, and postoperative UDVA were excellent. Despite a broad range of treatments with the preoperative sphere ranging from -8.75 to -0.25 D and cylinder up to 5.00 D, most eyes (75.5%) achieved 20/16 monocular UDVA or better 1 month after surgery. The binocular uncorrected visual acuity was similarly excellent. The refractive predictability was also good because 93.0% and 99.6% were within 0.50 and 1.00 D of target, respectively. These results were similar to or better than previous studies of LASIK, although direct comparison was difficult because of differences in sample size, age, preoperative refractive error, examination techniques, and follow-

up time period.[8-20] **Table 5** displays a comparison of studies that have reported the outcomes of wavefront-guided LASIK.

A vector analysis[6,7] was used to analyze in detail the accuracy of astigmatic correction achieved with the LASIK treatments of the current series. Astigmatism is a vector parameter and a thorough analysis requires computation of change in both magnitude and axis. Three fundamental vectors were used in the astigmatic vector analysis: IRC, SIRC, and error vector.[6] The various relationships between these three vectors provided a complete description of the astigmatic correction achieved with the specific modality of treatment evaluated. The magnitude of the IRC and SIRC vectors would have been coincident and the magnitude of error vector would have been zero if the treatment performed a perfect astigmatic correction. In our study, the magnitude of IRC and SIRC were strongly correlated and the mean magnitude of the error vector was 0.15 D. This confirms the high predictability of the astigmatic correction achieved with the excimer laser equipment used in the current study. The mean difference between the magnitude of IRC and SIRC was essentially zero in all cases. Likewise, mean error of angle was approximately 1° in the evaluated sample, confirming the excellent alignment of the treatment correction. A total of 90.12% (219 eyes) of eyes showed an error of angle of 5° or less, which was also an excellent outcome.

The astigmatism results in particular compared favorably to other LASIK studies, but few studies have reported on detailed vector analysis of cylinder outcomes. Partal and Manche[21] studied LASIK for the treatment of myopia and myopic astigmatism using the VISX platform. Their mean preoperative cylinder was 0.80 and 0.42 D at 1 month, representing a 48% reduction in absolute astigmatism. This compared to our study with a mean preoperative and 1-month postoperative cylinder of 0.72 and 0.14 D, respectively, representing an 81% reduction. On vector analysis, they reported a correction ratio (defined as the quotient between the magnitudes of SIRC and IRC) of 0.92 compared to 1.00 in our study. Albarrán-Diego et al.[22] evaluated the efficacy, predictability, and safety of bitoric LASIK using the Bausch & Lomb excimer laser platform (Bausch & Lomb, Rochester, NY) for the correction of mixed astigmatism and found a correction ratio of 0.97 using vector analysis, a value lower than that found in our study. Rueda et al.[23] reported on 65 eyes with mixed and simple myopic astigmatism undergoing LASIK with a different laser system. They obtained a correction ratio of 0.80, which was a significantly lower value compared to that found in our study.

There may be several reasons for the improvement in astigmatism results, such as better measurement
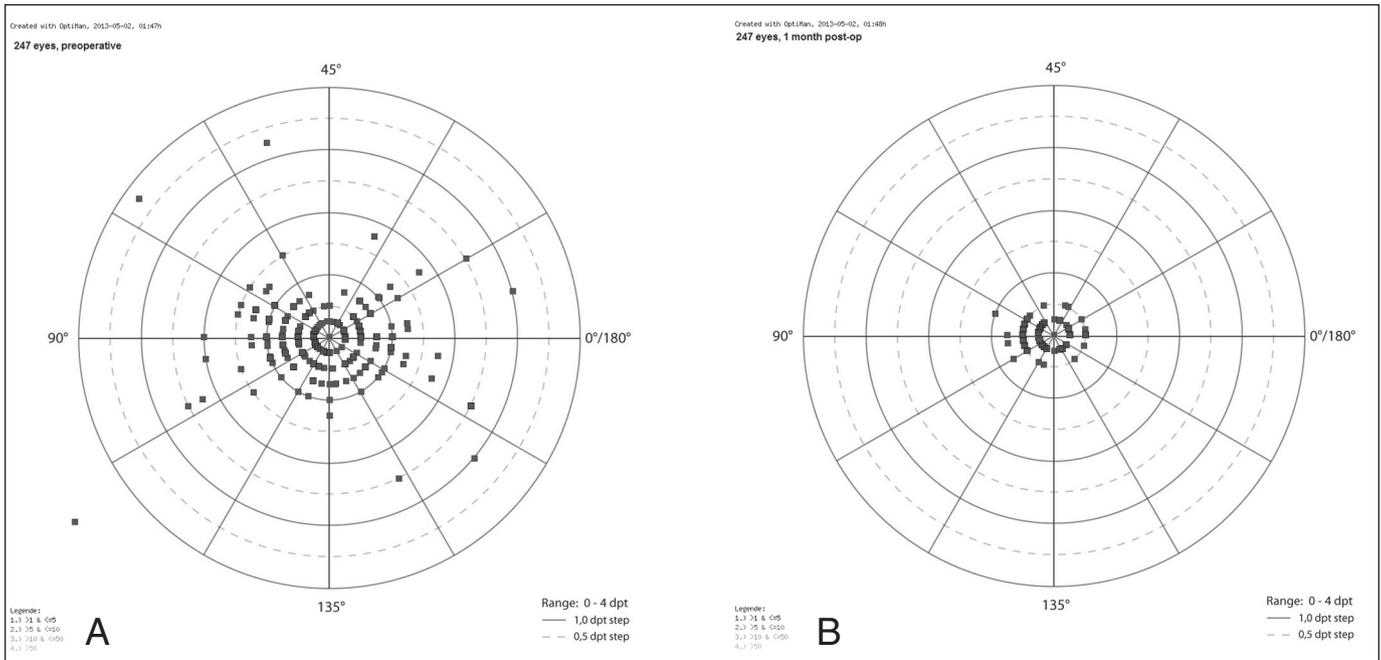
Figure 4. Distribution of the (A) preoperative and (B) postoperative refractive cylinder displayed in a double angle plot. DPT = diopter

TABLE 4

Results of the Vector Analysis of Refractive Astigmatism Changes 1 Month After LASIK Surgery

Vector Parameters	Mean (SD)	Median (Range)
IRC (D)	0.72 (0.67)	0.50 (0.00 to 5.00)
SIRC (D)	0.81 (0.62)	0.69 (0.00 to 4.52)
EV (D)	0.15 (0.21)	0.00 (0.00 to 1.00)
ER	0.25 (0.46)	0.00 (0.00 to 3.00)
CR	1.02 (0.30)	1.00 (0.00 to 2.24)
EM (D)	+0.01 (0.18)	0.00 (-0.50 to +0.50)
EA (º)	1.05 (11.82)	0.00 (-84.05 to 75.29)
Absolute EA (º)	3.30 (11.40)	0.00 (0.00 to 84.05)
Axis shift (º)	-1.54 (26.47)	0.00 (-85.00 to 85.00)

SD = standard deviation; IRC = intended refractive correction; D = diopters; SIRC = surgically induced refractive correction; EV = error vector; ER = error ratio; CR = correction ratio; EM = error of magnitude; EA = error of angle
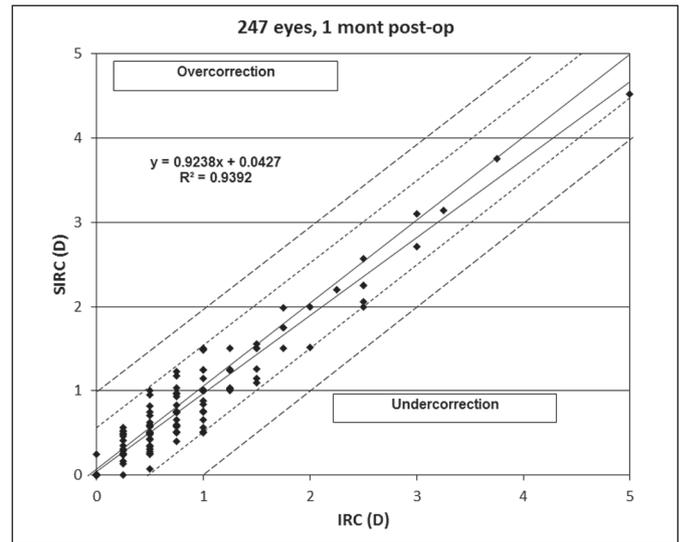
Figure 5. Scattergram showing the relationship between the magnitude of the surgically induced refractive correction (SIRC) at 1 month postoperatively and the intended refractive correction (IRC).

and better alignment of the ablation profile. With four times as many lenslets in the Hartmann-Shack imaging device and purportedly improved internal software, the new aberrometer may have greater precision to measure aberrations, including astigmatism. This improvement measurement may be either cylinder magnitude or a more precise axis determination. Although the literature is mixed on the value of previous iris registration technology,[1,24-26] the new device used an enhanced iris registration system, which may improve

rotational and directional alignment of the ablation profile. Even small rotational misalignments can significantly reduce the effectiveness of astigmatism treatment.[27] In addition, better directional alignment (x, y, and z planes) of the ablation may improve astigmatism outcomes. Directional misalignment of a myopic or hyperopic ablation induces coma, which can manifest as astigmatism.

Our myopic wavefront-guided treatments were performed using a simple nomogram to adjust for sphere

TABLE 5

Summary of the Visual and Refractive Outcomes of Other Wavefront-Guided LASIK Studies

Author (y)	Eyes	Preoperative SE (D) (range)	Excimer Laser	Postoperative UDVA 20/20 or Better	Postoperative SE ±0.50 D	Loss Two Lines CDVA	Follow-up
Current study	243	-0.38 to -9.88	VISX Star S4	93.4%	93%	0%	1 month
Ryan & O'Keefe[8] (2012)	42	-1.28 to -7.40	Technolas 217z100	81%	86.5%	3%	12 months
Perez-Straziota et al.[9] (2010)	66	-0.25 to -9.75	VISX Star S4	85%	96%	0%	3 months
Moshirfar et al.[10] (2010)	102	-1.53 to -8.07	VISX Star S4	82%	91%	0%	6 months
Keir et al.[11] (2009)	324	-0.25 to -6.50	LADAR-Vision 4000	84%	81%	0%	6 months
Schallhorn and Venter[12] (2009)	42,143	-0.37 to -6.00	VISX Star S4	92%	94%	0.7%	1 month
Awwad et al.[13] (2007)	50	-0.50 to -7.25	LADAR-Vision	94%	96%	0%	3 months
	50	-1.50 to -7.50	VISX Star S4	84%	96%	0%	
Wu et al.[14] (2009)	122	-1.63 to -6.63	MEL80 (with IR)	96.2%	–	0%	3 months
	122	-1.25 to -7.13	MEL80 (no IR)	92.3%	–	0%	
Stonecipher and Kezirian[15] (2008)	188	-0.25 to -7.00	ALLEGRETTO WAVE	93%	93%	0%	3 months
Zhou et al.[16] (2007)	56	-1.25 to -9.75	ESIRIS	94%	95%	0%	12 months
Alió and Montés-Micó[17] (2006)	20	-2.01 ± 1.36[a]	Technolas 217z	–	94%	0%	6 months
Jabbur et al.[18] (2005)	277	-0.80 to -6.50	VISX Star S4	94%	90%	0%	6 months
Kanjani et al.[19] (2004)	150	-0.87 to -15.00	Technolas 217	69.9%	79.9%	2%	6 months
Kohnen et al.[20] (2004)	97	-0.25 to -9.00	Technolas 217	83%	77%	0%	12 months

SE = spherical equivalent; D = diopters; IR = iris recognition; UDVA = uncorrected distance visual acuity; CDVA = corrected distance visual acuity
[a]Range not reported.
The VISX Star is manufactured by Abbott Medical Optics, Inc., Santa Ana, CA, the Technolas 217z100, 217z, and 217 are manufactured by Technolas Perfect Vision GmbH, Munich, Germany, the LADAR-Vision 4000 and Allegretto Wave are manufactured by Alcon Laboratories, Inc., Fort Worth, TX, the MEL80 is manufactured by Carl Zeiss Meditec, Jena, Germany, and the Esiris is manufactured by SCHWIND eye-tech-solutions, Kleinostheim, Germany.

overcorrection when treating higher levels of cylinder. Although the sample size of patients with high astigmatism was small, this nomogram appeared effective. Although the 1-month mean manifest spherical equivalent results indicated a good target, a longer follow-up is needed to ascertain the need for additional nomogram adjustments.

The subjective questionnaire revealed that most patients who answered the survey were satisfied with the outcome (98.5%) and all patients would recommend the procedure to others and confirmed that their expectations were met or exceeded. This is similar to patient satisfaction that has been previously reported after LASIK.[28,29] Yu et al.[29] found a total of 95% of patients in a sample of myopes undergoing wavefront-guided LASIK were satisfied with the surgery and would recommend the procedure to a friend or family member. Awwad et al.[28] evaluated quality of life changes after wavefront-guided LASIK in myopic patients ranging from -1.00 to -7.50 D and found that there was a significant improvement in quality of life after surgery,

with the main changes pertaining to psychological well-being and social role, more than the changes in visual function.

The most important limitation of this study was that it was retrospective and, as such, bias could be introduced through subject selection, examination techniques, or lack of follow-up. To reduce this bias, defined and straightforward criteria were used, the most important of which was to include consecutive primary LASIK treatments. All patients attended the 1-month postoperative examination, which eliminated follow-up bias. However, only approximately 50% of patients completed the questionnaire. Another limitation is that long-term results were not evaluated. This study was intended to be an initial evaluation and, as such, a relatively short follow-up period (1 month) was chosen. A longer follow-up is often desirable to study other aspects of surgery, such as refractive stability and change in visual symptoms. Finally, we were not able to assess change in higher-order aberrations with this study. This is an important outcome of a LASIK evalu-

ation, especially of a wavefront-guided procedure, and therefore should be studied using the new aberrometer in future studies.

The results are encouraging for this initial evaluation of a new aberrometer to derive the ablation profile for myopic LASIK treatment. There was good refractive predictability, particularly cylinder correction, and a high level of achieved UCVA and patient reported satisfaction. Larger studies with longer follow-up are needed to more fully evaluate the procedure.

AUTHOR CONTRIBUTIONS

Study concept and design (SS, MB); data collection (MB, JV, DT, KH); analysis and interpretation of data (SS, MB, KH, HY); drafting of the manuscript (SS); critical revision of the manuscript (SS, MB, JV, DT, KH, HY); statistical expertise (SS, KH); administrative, technical, or material support (SS, MB); supervision (SS, MB)

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