Laser in situ keratomileusis for myopia and the contrast sensitivity function

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Purpose: To characterize the clinical effects of laser in situ keratomileusis (LASIK) on the cornea and visual performance by the contrast sensitivity function (CSF).

Setting: Clinique d'Ophtalmologie IRIS, Laval, Quebec, Canada.

Methods: Thirty-four patients aged 18 to 50 years volunteered for this prospective study. All patients had bilateral LASIK to correct myopia between −1.00 and −6.75 diopters (D) and refractive astigmatism less than 2.50 D. The mean spherical equivalent (SE) refractive error in the 68 eyes was −3.93 D ± 1.67 (SD). A Hansatome® microkeratome (Bausch & Lomb) and a Technolas® 217C excimer laser (Bausch & Lomb) driven by the PlanoScan program were used. The monocular CSF for spatial frequencies of 3, 6, 12, and 18 cycles per degree (cpd) for both day and night vision simulations were made with a CSV-1000E system (Vector Vision) before and 1 month and up to 9 months after LASIK. All patients wore their best spectacle correction for the baseline CSF.

Results: The group (n = 68) averaged preoperative and postoperative CSFs did not differ at 1 month (analysis of variance [ANOVA], $P>.05$). In a subgroup of 11 eyes that had corneal microstriae, however, there was a significant reduction in the photopic and mesopic CSF at 6, 12, and 18 cpd (ANOVA, $P<.05$) despite normal Snellen visual acuities. The CSF normalized in 6 to 9 months as the microstriae became less visible.

Conclusions: Subtle central corneal microstriae after LASIK can reduce the baseline CSF at medium to high spatial frequencies even with 20/20 visual acuity. The CSF normalizes as the microstriae fade over time.

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Laser in situ keratomileusis (LASIK) is arguably the most widely used corrective surgical procedure for myopia below 7.0 diopters (D).[1] Nonetheless, there is a need for more information on clinical outcomes of LASIK and any effects on the cornea that impair visual performance in varying ambient light. The practical importance of such knowledge was demonstrated by Owsley et al.,[2] who found that drivers involved in car accidents were 6 times more likely to have had severe impairment of their contrast sensitivity function (CSF) in 1 or both eyes despite normal Snellen visual acuity. This seminal study helped establish the CSF as a clinical index predictive of a person's visual performance in day and night vision driving. The CSF has also been used to diagnose subclinical neuronal dysfunction, track subtle changes in vision after therapeutic interventions,[3,4] and explain patient complaints of inadequate vision after refractive surgery that provided 20/20 (6/6 metric) visual acuity.

Unfortunately, the results of most studies of the effects of refractive surgery on CSF[5–9] cannot be applied to current LASIK procedures because studies used a wide laser beam for stromal ablation,[5–9] examined patients with high degrees of myopia (mean spherical equivalent

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greater than or equal to −6.00 D),[6–10] evaluated only the photopic CSF,[6,10–13] or used the now-outdated photorefractive keratectomy (PRK) approach. Furthermore, only a few studies have attempted to determine the cause of generalized or frequency-specific reductions in the CSF. For example, Holladay and coauthors[6] concluded that the oblate shape of the cornea was the principal factor that reduced the CSF. In a later study, Marcos[14] correlated a reduction in the CSF with a decrease in the modulation transfer function (MTF) but did not correlate these with specific corneal abnormalities. Irregular corneal astigmatism[15] and the size of the treatment zone[16] have been linked with a decreased CSF but only in patients who had PRK surgery.

Surprisingly, although corneal striae resulting from slippage and folding of the corneal flap in the stromal bed[17–22] are recognized as frequent complications of LASIK that must be avoided,[18–21,23–25] their effect on the CSF has not been examined to date. Collectively, these studies highlight a significant gap in our understanding of the consequences of LASIK surgery on the upper limits of visual performance, as quantified by the photopic and mesopic CSF.

Consequently, we undertook this study with the general objective of demonstrating the effectiveness of CSF measurements in the day-to-day management of patients treated with LASIK. This study was restricted to patients with less than 7.0 D of myopia who had contemporary LASIK procedures, including larger ablation zones and a computer-guided scanning spot laser. Our specific research objectives were to differentiate the effects of LASIK on the photopic versus the mesopic CSF and to identify any physiologic or optical corneal factors that could negatively affect the preoperative CSF. Results from this study may lead to more reliable and routine implementation of the CSF as a prognostic index for visual outcomes after LASIK correction of myopia.

Patients and Methods

Thirty-four adults (18 men and 16 women) with a mean age of 34.7 years ± 7.6 (SD) (range 18 to 50 years) volunteered for this study. The range of spherical refractive error was −0.25 to −6.75 D; range of astigmatism was 0.00 to −2.25 D. The mean spherical equivalent (SE) refractive error before LASIK was −3.93 ± 1.67 D indicating that the majority of patients had low to moderate myopia. The study inclusion criteria included Snellen best corrected visual acuity (BCVA) of 20/20 (6/6 metric) or better, a normal CSF profile before LASIK surgery, a stable refraction over the previous 12 months, and no current or previous ocular surgery or pathology. Patients with myopia higher than −7.00 D were excluded from the study because high-power spectacles are known to induce significant aberrations that can artificially degrade the threshold measurements of contrast sensitivity.[26–27] Exclusion criteria included inability to comply with all test procedures, systemic vascular diseases with known effects on ocular blood flow, any vasoactive ocular medications, and any opacification of the ocular media.

The preoperative eye examination included a case history, measurements of Snellen visual acuity and refractive errors, a slitlamp examination of the anterior segment, a dilated fundus examination, and measurements of intraocular pressure and horizontal pupil diameters in photopic and mesopic illumination. More specialized testing included a detailed assessment of corneal topography using the Keratron corneal topographer and corneal thickness using an ultrasonic pachymeter (Biovision International).

The same series of tests (except without tonometry, pachymetry, and dilated fundus examination) were carried out 1 week and 1 month after LASIK. For the 34 patients enrolled in the study, all postoperative visual symptoms were documented and correlations between these and any changes in the basal CSF measurements were looked for.

All patients were informed about the nature of testing and their right to withdraw from the study at any time for whatever reason without prejudice for continued eye care. An approved ethics form for the use of humans in research was signed by each subject before the procedure. All participants were guaranteed anonymity through coding of results by number or initials and group averaging of data across subjects.

LASIK Surgery

Standard LASIK surgery was performed using a narrow beam (2.0-mm), flying-spot scanning excimer laser (Technolas 217C) equipped with the PlanoScan program (Bausch & Lomb). This laser has an emission wavelength of 193 nm, a fixed pulse rate of 50 Hz, and irradiation of 120 mJ/cm^2. A fluence test was performed before each surgery to ensure proper operation of the laser. An eye-tracking system linked to the laser activation system ensured that ablation was performed only in the targeted areas of the cornea. The flap diameter, with a target thickness of 160 μm, varied from 8.5 to 9.5 mm (mean diameter 8.9 mm). As shown in Table 1, the central ablation zone ranged from 5.5 to 7.0 mm with a transition zone. All LASIK surgeries were performed by the same experienced surgeons (C.F. or M.B.) at the Clinique d'Ophtalmologie IRIS, Canada.

After surgery, patients were prescribed ofloxacin 0.3% (Ocuflox®) and fluorometholone 0.1% (FML Liquifilm®) 4 times a day for 1 week.

Table 1. Characteristics of treated eyes.

		Range	
	Mean ± SD	Min	Max
All eyes treated (n = 68)			
Preoperative sphere (D)	−3.50 ± 1.67	−0.25	−6.75
Preoperative astigmatism (D)	1.00 ± 0.62	0.00	2.25
Preoperative spherical equivalent (D)	−3.93 ± 1.67	−1.00	−7.25
Mean keratometric power (D)	43.76 ± 1.84	40.44	48.24
Corneal thickness (μm)	551 ± 30	478	620
Residual stromal bed (μm)	297 ± 44	232	398
Scotopic pupil diameter (mm)	6.39 ± 0.71	4.0	8.0
Ablation zone diameter (mm)*	6.7 ± 0.43	5.5	7.0
Postoperative defocus equivalent (D)	0.49 ± 0.32	0.00	1.50
Eyes with microstriae (n = 11)			
Preoperative sphere (D)	−5.21 ± 1.00	−3.25	−6.25
Preoperative astigmatism (D)	0.98 ± 0.59	0.00	2.00
Preoperative spherical equivalent (D)	−5.61 ± 1.02	−3.87	−7.25
Mean keratometric power (D)	44.46 ± 1.67	42.40	48.24
Corneal thickness (μm)	550 ± 18	522	580
Residual stromal bed (μm)	256 ± 14	232	281
Scotopic pupil diameter (mm)	6.03 ± 1.09	4.0	7.8
Ablation zone diameter (mm)†	6.8 ± 0.27	6.2	7.0
Postoperative defocus equivalent (D)	0.56 ± 0.31	0.00	0.88

*4 eyes between 5.9 and 5.5 mm, 14 eyes between 6.4 and 6.0 mm, 50 eyes between 7.0 and 6.5 mm

†4 eyes between 6.5 and 6.2 mm, 7 eyes between 7.0 and 6.7 mm

Contrast Sensitivity Instrument and Testing Procedures

Chronologically, CSF testing was carried out and then analyzed in 3 groups of patients:

1. A group of 12 eyes from 6 patients selected at random at the start of the study to confirm the sensitivity of the CSF to detect postoperative changes in the cornea. For this group, the CSF was measured 1 week and 1 month after LASIK.
2. All patients together when the full complement of patients volunteering for the study was completed. In these, the CSF was measured before surgery and about 1 month (mean 36 days) after LASIK.
3. A second group of 11 eyes from 6 patients identified from within the full cohort of subjects as having losses in sensitivity greater than the CSV-1000 test-retest variability (test-retest mean difference plus 2 SD) for each of the 4 spatial frequencies studied.[4]

These eyes were also identified by an ophthalmologist blind to the results of CSF testing as having microstriae in the central area of the corneal flap.

For all patients, postoperative CSF testing was monocular and performed by examiners who were masked to preoperative (baseline) CSF scores. The CSF was evaluated with a Vector Vision CSV-1000 system (Figure 1) that had been used in previous studies examining the effects of various treatments or refractive surgeries on visual performance indexed by the CSF[4,5,7,8,16,28] and that readily yielded reliable and repeatable CSF scores. The CSV-1000E system consisted of a retroilluminated chart with a mean luminance of 85 cd/m^2 (high photopic conditions) that displayed 4 rows of circular patches with sine-wave gratings with decreasing contrast. The uppermost row tested contrast sensitivity for gratings at 3 cycles per degree (cpd) (contrast range 0.70 to 2.08 log units), and the second, third, and fourth rows assessed contrast sensitivity for 6 cpd (contrast range 0.91 to 2.29 log units), 12 cpd (contrast range 0.61 to 1.99 log units), and 18 cpd (contrast range 0.17 to 1.55 log units), respectively. Each row in the test plate displayed 4 vertically aligned pairs of circles, 1 of which contained decreasing contrast targets for a single spatial frequency, whereas the opposite circle was a gray patch with a space-averaged luminance equal to that of the circle with the sine-wave grating. A critical feature of the CSV-1000E is its autocalibration by which a built-in light sensor measures the ambient light and continuously adjusts the internal lighting for the retroillumi-

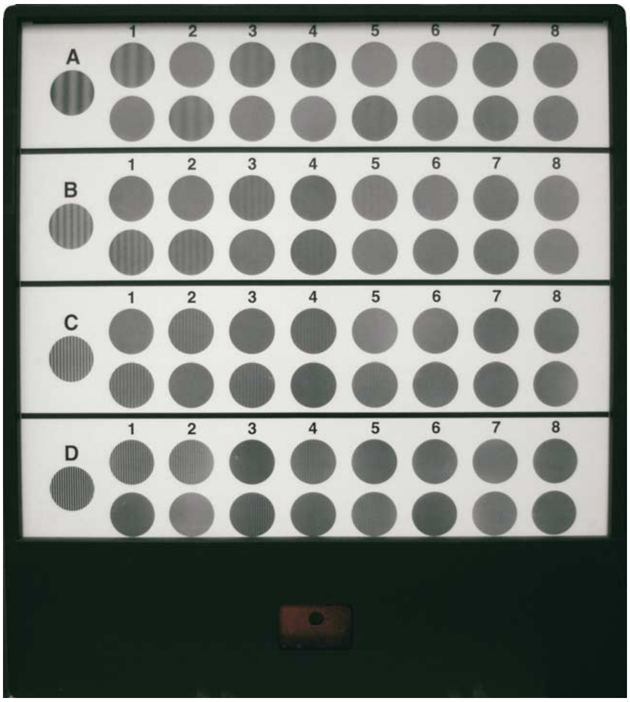

Figure 1. (Quesnel) The appearance of the Vector Vision CSV-1000E chart as seen by the patient.

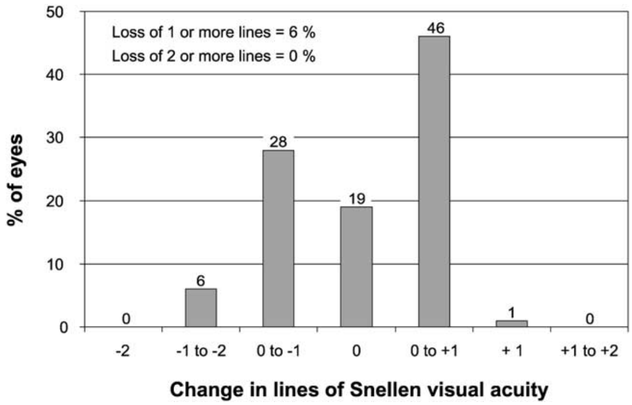

Figure 2. (Quesnel) Bar graph showing the change in the best spectacle-corrected visual acuity (BSCVA) measured preoperatively to the acuity measured 1 month post-LASIK. The change is expressed as the number of Snellen lines for all eyes in the study (n = 68). A change of 1 Snellen line or less was considered within the range of normal biological variability for repeated measures and therefore not a real change.

nated translucent CSF test plate to maintain targets at a constant contrast within and across measurement sessions.

During the determination of the baseline CSF, the chart was viewed from a distance of 8 feet (2.4 m) with the patient's best optical correction in place. After an initial demonstration of the CSF test procedure, the contrast threshold was measured for each spatial frequency, first for the right eye and then the left in each patient. The threshold for a specific spatial frequency was determined by having the patient identify the vertical pair of circles within each row in which the sine-wave grating and its corresponding gray patch could not be distinguished. All patients were tested first in normal room lighting where the reflected luminance of the test pattern at the patient's facial plane was 295 lux. After 5 minutes of adaptation to lowered ambient lighting, the CSF measurement procedure was repeated for mesopic light levels (0.45 lux at facial plane). The contrast threshold scores were recorded on a logarithmic scale CSF chart. For all patients, monocular thresholds were derived with the best spectacle correction worn before surgery and without an optical correction after LASIK. At 1 month post-LASIK, for patients with a residual refractive error over ±0.50 D in 1 principal meridian (8 eyes of 6 patients), a second series of CSF measurements was made with the best optical correction.

One month after LASIK surgery, the quality of vision was also assessed via a questionnaire to standardize the subjective impression of the quality of vision at nighttime and the degree of any visual disturbances such as glare or halos around lights.

Statistical Analyses of Data Trends

Logarithmic contrast sensitivity values were used for statistical analyses performed using SPSS (version 11.0.1) for Microsoft Windows. All data were evaluated for statistical significance with an analysis of variance (ANOVA) for an alpha of 5% and post hoc statistics to identify which postoperative spatial frequencies differed from the baseline CSF score.

Results

One month after surgery, the mean manifest postoperative SE refraction was −0.01 ± 0.32 D with a range of +0.75 to −0.75 D. The target spherical refractive error within ±0.50 D was attained in 94% of all patients. The defocus equivalent of Holladay and coauthors[29] was also calculated and is presented in Table 1. Other relevant optical and corneal characteristics of the 68 test eyes and those of the 11 eyes exhibiting flap microstriae are presented in Table 1. The bar graph of Figure 2 presents the changes in the best spectacle-corrected visual acuity (BSCVA) before surgery and 1 month after surgery expressed as the number of Snellen visual acuity lines lost or gained. No eye lost more than 2 lines of the BSCVA, and only 4 eyes (6%) lost 1 line of BSCVA after LASIK. Only 1 eye gained 1 line of BSCVA. The BSCVA was 20/20 (6/6 metric) or better in 67 of 68 eyes (98.5%) and 20/25 (6/7.5) or better in 100% of the LASIK eyes. The uncorrected Snellen

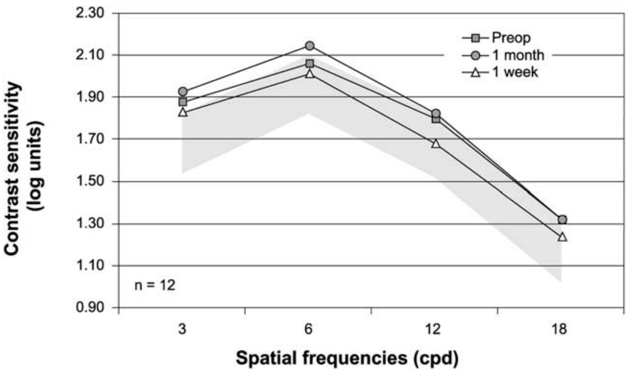

Figure 3. (Quesnel) Contrast sensitivity function profiles for a random group of 6 patients (12 eyes) before LASIK and 1 week and 1 month after LASIK. The photopic CSF was significantly reduced below the baseline scores 1 week after LASIK for 12 and 18 cpd. By 1 month, the photopic CSF scores even exceeded the baseline scores, but these were not significantly different. For this and all subsequent figures illustrating contrast sensitivity curves, the grey zone displays the range of contrast sensitivities for normal subjects between the ages of 20 and 59 years.

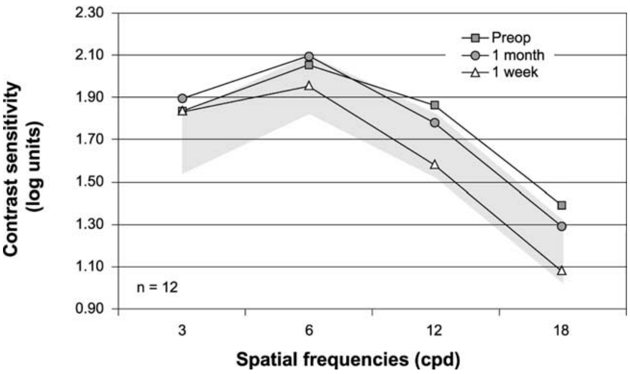

Figure 4. (Quesnel) Contrast sensitivity function profiles for a random group of 6 patients (12 eyes) before LASIK and 1 week and 1 month after LASIK. The mesopic CSF was significantly reduced below the baseline scores 1 week after LASIK, more so between 6 and 18 cpd. By 1 month, the mesopic CSF had returned to normal at all spatial frequencies ($P>.05$).

visual acuity was 20/20 or better in 81% of eyes and 20/25 or better in 100%.

The CSF profiles reported for 1 month post-LASIK were based on results without spectacles for all patients. There was no significant difference (ANOVA, $P>.05$) between the CSF profiles without the BSCVA and the CSF profiles with the best spectacle correction for the 8 eyes tested in both conditions. The mean manifest postoperative SE was -0.16 ± 0.55 D with a range of $+0.75$ to -0.75 D.

Figures 3 and 4 present the photopic and mesopic CSF profiles, respectively, for the first subgroup of 12 eyes of 6 patients selected randomly to confirm the sensitivity of the CSF for tracking the resolution of surgically induced defects in the cornea. The CSF in this group was measured 1 week and 1 month after LASIK. At the 1-week mark, the mesopic CSF, although within some reported ranges of CSF normal,[4] was significantly reduced at 6 cpd, 12 cpd, and 18 cpd ($P<.05$) and more so than the reductions found for the photopic CSF. One month after surgery, however, all CSF measurements had normalized to baseline levels ($P>.05$). These findings confirmed the ability of the CSF to quantify improvements in visual performance over time after LASIK. These CSF data also suggest that the cornea may be fully recovered form stromal ablation as early as 1 month following LASIK.

Figures 5 and 6 show the photopic and mesopic CSF profiles, respectively, for all subjects (n = 68 eyes) enrolled in the study at baseline and 1 month after

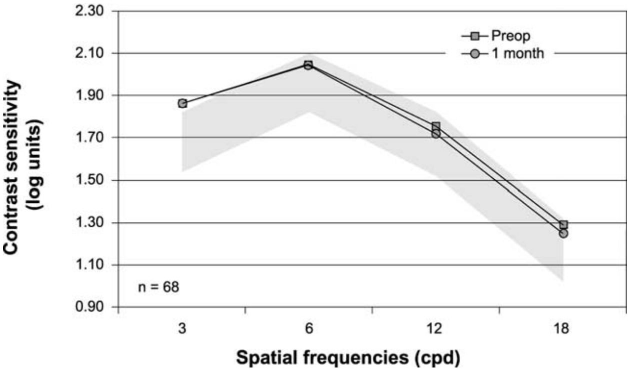

Figure 5. (Quesnel) One month after LASIK, the mean photopic contrast sensitivity function (CSF) profiles (n = 68) did not differ from the presurgical scores at any spatial frequency.

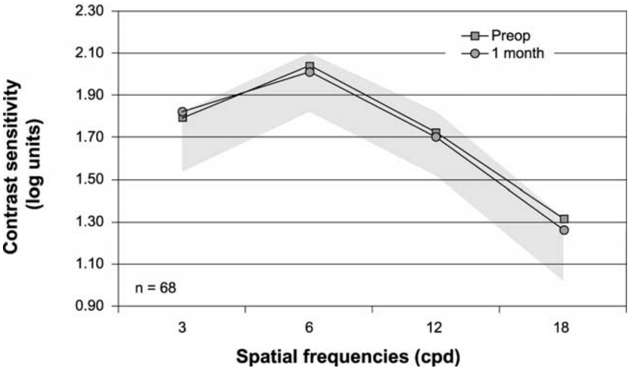

Figure 6. (Quesnel) One month after LASIK, mean mesopic CSF profiles (n = 68) did not differ from the presurgical scores at any spatial frequency.

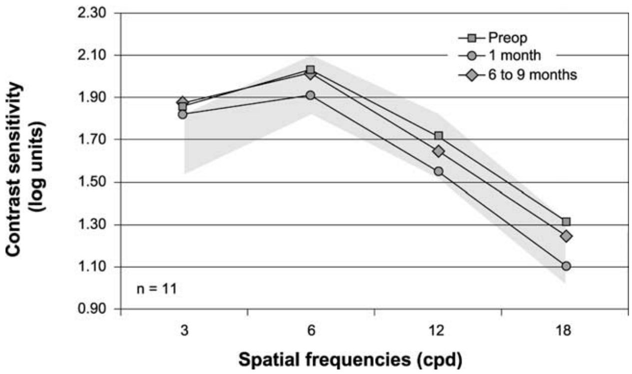

Figure 7. (Quesnel) One month after LASIK surgery, residual central corneal microstriae significantly reduced the photopic CSF from 6 to 18 cpd in another cohort of 6 patients (n = 11 eyes). At 6 to 9 months, however, the CSF scores had returned to normal at all spatial frequencies.

LASIK. Statistical analyses indicated that there was no significant difference between the mean CSF profiles before and 1 month after LASIK at all spatial frequencies ($P>.05$), again suggesting full recovery of the cornea from stromal ablation just 1 month after surgery.

Figures 7 and 8 illustrate the preoperative and postoperative photopic and mesopic CSF profiles, respectively, for the third group of eyes that were uniquely characterized by central corneal microstriae,[20] which were best observed on retroillumination at the slitlamp. Unlike eyes without microstriae, this group still demonstrated a significant reduction in contrast sensitivity for middle to high spatial frequencies (6, 12, and 18 cpd) 1 month post-LASIK ($P<.05$). As a result of the persistent attenuation of contrast sensitivity by 1 month, this group of eyes was monitored closely until all CSF deficits disappeared. The data in Figures 7 and 8 show that the CSF at all frequencies returned to the preoperative levels after 6 to 9 months ($P>.05$). During this same interval, the microstriae also gradually became invisible to slitlamp biomicroscopy. Only 1 eye with corneal microstriae lost 1 line of the BSCVA, thereby revealing the superior sensitivity of the CSF for disclosing residual corneal defects affecting the visual performance that otherwise may have remained undetected because of normal letter resolution.

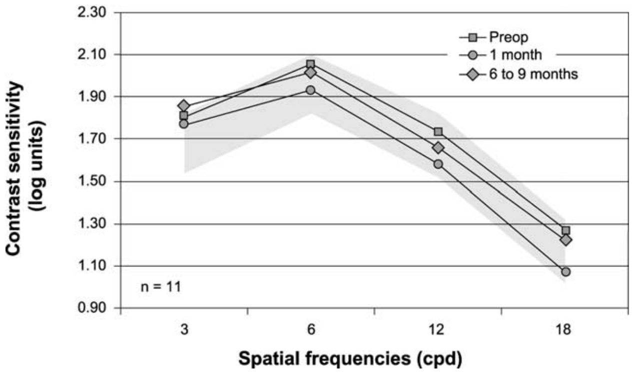

Figure 8. (Quesnel) One month after LASIK surgery, the residual central corneal microstriae also significantly reduced the mesopic CSF from 6 to 18 cpd in the same cohort of 6 patients (n = 11 eyes) as described in Figure 7. As for the photopic CSF, the mesopic CSF also returned to normal at all spatial frequencies within 6 to 9 months.

The surgical approach producing normal CSF profiles by 1 month translated into strong patient satisfaction with the quality of vision. Specifically, complaints of difficulty with nighttime driving did not increase after refractive surgery, and only 12 patients, including 4 with microstriae, reported nondisturbing grade 1 halos; 4 patients, including 1 with microstriae, reported grade 1 glare.

Discussion

Previous studies have reported a reduction in the CSF at all or some spatial frequencies 1 month or longer after LASIK surgery.[7–9,30] According to most studies, this reduction in contrast sensitivity lasted for 3 months[5,7,8,30] or 6 months[6,9] for intermediate and higher spatial frequencies that are typically compromised by defocus and optical aberrations.

In this study, we found that the postoperative CSF returned to preoperative values in 1 month when the cornea did not have microstriae. This finding demonstrated the clinical utility of the CSV-1000E system for detecting subtle physiologically induced defects in the cornea secondary to a surgical remodeling of the stroma. This capability will ultimately allow refractive surgeons to work at very fine levels of refractive correction and visual performance beyond a 20/20 letter acuity. This major improvement in postoperative visual outcome is most likely due to significant technological advances for controlling the smoothness of the ablation zone through computer-guided laser scanning of the cornea[12] and also by simpler, more practical changes such as increasing the ablation zone from 5.0 to 6.5 mm.[12] In addition, CSF measurement procedures have improved to attain better patient compliance and consequently increase the capability to detect subtle corneal abnormalities that impair visual function.

Overall, our results are consistent with those of Knorz and coauthors,[10] who reported no difference in mesopic vision for corrections of less than −5.00 D with the Keracor 117C laser and the Automated Corneal Shaper microkeratome chiron. Our finding that the mesopic CSF scores paralleled the photopic scores after LASIK may have been strongly influenced, however, by the fact that the mesopic pupil diameter fell within the ablation zone in about 75% of our patients. The clinical implication of this observation is that refractive surgeons can optimize a patient's visual performance for most viewing conditions by keeping the ablation zone within the mesopic pupil whenever possible.

The frequency-specific reduction in the postoperative CSF for the subgroup of patients with microstriae can be attributed to the loss of 2 normal optical features of the cornea: homogeneous refraction and transparency.[31] It is well known that corneal transparency relies on destructive interference of scattered light by the regular arrangement of the stromal collagen fibers; this latter feature of the cornea is likely altered by the microstriae or is the consequence of focal disarray in the stromal collagen fibers. Any disruption of the regular arrangement of the collagen fiber matrix alters corneal transparency that may not be easily detected by traditional clinical measurements of visual acuity but are measurable when visual performance is evaluated by the CSF. The reduction in CSF cannot be attributed to optical defocus because measurements with and without the best optical correction yielded to similar results.

There are several causes of corneal striae related to LASIK, including flap desiccation and contraction during laser ablation, flap wrinkling during stretching, and flap misalignment.[32] Central flap striae are believed to be due to the "tenting" effect of the corneal flap over the ablated stromal bed, a condition that tends to occur more frequently in surgical corrections of high myopia.[20,21] Tables 1 and 2 show that the preoperative mean SE refractive error for the eyes with microstriae was −5.61 D compared with −3.93 D for all eyes included in the study. Marcos[14] has shown that high-resolution visual acuity was not particularly sensitive to the LASIK-induced changes in image quality. In our study, only 1 eye of 11 with corneal microstriae lost 1 line of BSCVA, confirming that the CSF is more capable of detecting a reduction in visual performance after a LASIK correction of myopia.

Longitudinal changes in corneal microstriae without visual consequences have not been described extensively in the vision literature.[32] Our experience has been that they resolve spontaneously with time, most likely because of corneal remodeling. For the 11 eyes that had microstriae, their resolution over time can explain the return of the CSF back toward preoperative values 6 to 9 months after LASIK. For this subgroup of patients, our results are in agreement with those of Montés-Micó and Charman,[9] who reported that patients who had LASIK surgery regained their baseline CSF only after 6 to 12 months, especially for higher spatial frequencies that are more affected by optical factors such as the microstriae. Although Holladay and coauthors[6] concluded that the oblate shape of the cornea after LASIK was the dominant factor for the deterioration of visual resolution including reduced contrast sensitivity, they did not comment whether their patients had any visible striae or folds that also could have explained the reduced CSF.

Based on a questionnaire, El Danasoury[33] found that 49% of eyes reported glare after LASIK with an optical zone of 5.5 mm. Farah and coauthors[34] cited several studies that reported night-driving difficulties and glare ranging from 2% to 55.6% at 6 months. We presume that the use of the PlanoScan software and optical zones ranging from 6 to 7 mm for most patients allowed us to obtain better vision acuity as measured by the CSF and less cases of night-driving complications postoperatively compared with previous studies that have used broad-beam ablations. This observation suggests that despite the absence of patient complaints of night-vision problems, the ablation zone may have to be even wider to prevent peripheral aberrations that affect nighttime vision because the physiologically dilated pupil may sometimes exceed the ablation zone when driving in near total darkness versus the low ambient lighting in which the mesopic CSF was measured.

Our findings of reduced sensitivity for medium and higher spatial frequencies for the subgroup tested at 1 week postoperatively and the subgroup with microstriae are consistent with all other recent studies on this issue to our knowledge. In a recent study of the effects of LASIK on the CSF, however, Chan and coauthors[35] reported decreased sensitivity for low-frequency targets at low contrast levels after LASIK and suggested that insufficient sensitivity in earlier CSF measurements systems resulted in misleading findings. This explanation is difficult to accept because our mesopic CSF test conditions included low spatial frequency targets at low contrast and no deficits were found at the 3 cpd test pattern. It is more likely that the apparent discrepancy in findings was actually caused by a significant difference in the degree of myopia corrected in these studies.

The mean SE refractive errors were -3.93 ± 1.67 D for our patients and -6.03 ± 2.28 D for patients in the Chan study. Because the shape of the stromal ablation needed to correct low versus high myopia differs significantly as a result of the greater depth of tissue ablation required for high myopia, it is likely that the corneal flap undergoes more bending in higher myopia to fit the altered convexity of the ablated stromal bed. This may alter the spatial frequency for which contrast sensitivity is decreased. Empirical support for this notion is found in the recent report by Lee and coauthors,[36] who examined the interaction between the dioptric correction by LASIK and visual function indexed by the CSF. These researchers reported that LASIK correction of moderate myopia (-3.5 to -7.0 D) resulted in a loss of contrast sensitivity at 1.5, 3, 6, 12, and 18 cpd whereas correction of high myopia (-7.0 to -10.0 D) decreased sensitivity for the 1.5 and 3.0 cpd targets for daytime and nighttime conditions, respectively. These results implicate the degree of refractive error that is corrected, not the CSF measurement system as the principal variable leading to frequency-specific losses in contrast sensitivity.

It is significant that no recent study has been able to associate clinically detectable corneal defects with decrements in the CSF. In this regard, we believe that our study is the first to link surgically induced microstriae with decrements in the CSF as well as a resolution of microstriae with normalization of the CSF. Clinically, it is advisable to look for corneal microstriae as an index of the degree of surgical success because their presence reduces contrast sensitivity and may help explain dissatisfaction among patients with 20/20 visual acuity following surgery.

The preoperative CSF is unaffected 1 month after LASIK correction for myopia up to a mean SE of about -3.93 D, except when flap microstriae develop in the central corneal zone.

It is important to identify clinically significant folds or striae early during follow-up visits because treatment at that time is most successful.[20] Subtle microstriae in the corneal flap can reduce visual performance of the eye even if the BSCVA is 20/20 (6/6 metric) and not impaired.

Preventing folds and striae provides better visual outcomes and a significant improvement in patient satisfaction. Surgically, care should be taken to ensure uniform sponge smoothing of the flap to prevent radial or circumferential folds.[32] Another important measure to minimize the development of microstriae is to encourage eyelid closure in the first few hours after surgery, this reduces the possibility of flap displacement caused by blinking.[32]

Further improvements in visual quality that could likely be obtained by wavefront-guided ablations[37,38] are still dependent on the response of the cornea to the trauma of refractive surgery and flap-related difficulties. To maintain preoperative visual performance, it is desirable not only to limit aberrations in the postoperative cornea but also to maintain a smooth and clear corneal surface. Refractive surgeons should pay attention to the quality of the flap and carefully smooth the corneal surface at the end of the refractive surgery.

Because most LASIK complications are related to the creation of the corneal flap, newer surgical techniques under investigation, such as intrastromal ablation using ultra-short laser pulses, may lead to superior visual outcomes by eliminating the formation of a flap.[39]

Further follow-up and additional cases must be reviewed to draw conclusions about the long- and short-term effects of corneal microstriae on the CSF.

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