

Contrast sensitivity after excimer laser photorefractive keratectomy for myopia

Mahmoud Jabbarvand, Javad Bakhshi, Mohammad Taher Rajabi

Tehran University Eye Research Center, Farabi Eye Hospital, Tehran, Iran

Correspondence to: Mohammad Taher Rajabi. Eye Research Center, Farabi Eye Hospital, South Kargar ST, Tehran, Iran. mt_rajabi@yahoo.com

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Abstract

- **AIM:** To evaluate contrast sensitivity in patients who had undergone uncomplicated excimer laser photorefractive keratectomy (PRK) for myopia.
- **METHODS:** Monocular contrast sensitivity function was measured with the CSV-I000E chart in 41 patients who had received PRK by the Nidek EC-5000 excimer laser system. Mean preoperative refractive error was -2.62 ± 1.33 D (range, -0.75 to -4.00 D). Contrast sensitivity function was measured preoperatively, 1 week, 1, 3 and 6 months after surgery through the CSV-1000E contrast sensitivity unit (VectorVision).
- **RESULTS:** Logarithmic values of contrast sensitivity at each spatial frequency were used for statistical analysis and normalized values were used for graphical representation. Contrast sensitivity decreased 1 week and 1 month postoperatively. Starting from the first month, there was rapid recovery of contrast sensitivity especially at low spatial frequencies, and at the third month, only at 6 and 12 cycles per degree (cpd) statistically significant decrease was seen. Six months after surgery, there was an increase in contrast sensitivity values at all spatial frequencies.
- **CONCLUSION:** Photorefractive keratectomy can induce significant reductions in contrast sensitivity in the first month after surgery; these values returned to the preoperative values at 6 months after surgery.
- **KEYWORDS:** contrast sensitivity; excimer laser; myopia; photorefractive keratectomy

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INTRODUCTION

Correction of myopia, hyperopia and astigmatism within its indicated margin by means of refractive corneal surgical procedures such as LASIK and surface ablation (e.g. PRK) is one of the standard procedures in ophthalmology. Now that advances in the fields of surgical techniques and the technical devices employed have further progressed in terms of safety and predictability, research also focuses on optical quality. "Optical quality" is not a clearly defined parameter, but can be captured indirectly by means of directly measured data. One has to start with the anatomical properties of the eye, which determine the optical images on the retinal level. The quality of the retinal image influences the eye's function, i.e. acuity and contrast perception. Finally, there is the subjective perception of the image we receive. "Optical quality" as such is reflected by the patient's evaluation of this image perception. Three phenomena are especially responsible for deterioration of the quality of the retinal image: diffraction, aberrations and dispersion. Some of the methods for measuring optical quality are subjective questionnaires, functional testing procedures for measuring visual acuity and contrast sensitivity, optical measuring procedures for the determination of optical quality, as well as biomicroscopy, aberrometry and corneal topography for assessing anatomical changes.

Contrast sensitivity testing provides much more information about vision than Snellen acuity testing. Visual acuity measured by standard clinical tests is useful but is an incomplete description of visual ability. Although visual acuity tests determine the ability to resolve small details (i.e., resolution of high spatial frequencies) at high contrast, the visual environment is composed of objects with a variety of spatial frequencies and contrasts. Therefore, to determine how well one can function in a complex environment, it is necessary to measure sensitivity to contrast as a function of spatial frequency^[1-3].

In this study we evaluated the contrast sensitivity after PRK correcting low to moderate myopia.

Table 1 Preoperative vs postoperative contrast sensitivity values (Mean ± SD)

Spatial frequency (cpd)	Preoperative	Postoperatively			
		1wk	1mo	3mo	6mo
3	1.67±0.14	1.46±0.16	1.60±0.18	1.64±0.11	1.64±0.14
<i>P</i> value		0.000	0.021	0.144	0.264
6	1.93±0.15	1.68±0.21	1.85±0.14	1.83±0.22	1.89±0.21
<i>P</i> value		0.000	0.001	0.004	0.241
12	1.57±0.20	1.30±0.21	1.44±0.19	1.48±0.20	1.47±0.20
<i>P</i> value		0.000	0.000	0.007	0.006
18	1.17±0.21	1.00±0.23	1.00±0.23	1.13±0.16	1.17±0.21
<i>P</i> value		0.000	0.000	0.000	0.130

P values of postoperative versus preoperative

MATERIALS AND METHODS

Patients This prospective study comprised 82 eyes of 41 patients who had PRK by the same surgeon (MJ) from September 2003 to May 2004 at Farabi Eye Hospital, Tehran, Iran. Mean patient age was 27.78 years with 4.66 standard deviation (range 20 to 39 years). Preoperatively, mean refractive error was -2.62±1.33D(range -0.75 to -4.00D) and mean astigmatism, -0.66D (range 0.00 to -2.00D). Eyes with astigmatism greater than 2.50D were excluded.

Preoperative and 1 week, 1, 3 and 6 months postoperative examinations included visual acuity, manifest and cycloplegic refractions, slit-lamp microscopy, Goldmann applanation tonometry, indirect ophthalmoscopy, and contrast sensitivity testing (CSV-I000E, VectorVision).

Methods All PRK procedures were performed by the Nidek EC-5000 excimer laser system 193' nm argonfluoride. Topical anesthesia of tetracaine was used. After application of alcohol 700mL/L with ring for 30 seconds and removal of epithelium at central 9mm², the excimer laser ablation was performed on the stromal bed with an energy fence of 160mJ/cm² and a repetition rate of 34Hz. The photorefractive keratectomy (PRK) program was used without change. A multizone approach was used because the required ablation depth was lower than that with a large single zone and it achieves a smoother ablation profile. A triple ablation zone was used, with 50% of the correction done at the first zone, 30% at the second, and 20% at the third. The ablation profiles were 5.0, 5.5, and 6.0mm respectively.

Chloramphenicol and betamethasone eyedrops were instilled four times a day for the first 10 days. The CSV-I000E was used for contrast sensitivity testing. The unit, which is completely standardized, has a series of photocells and control circuitry that automatically monitor and adjust light intensity to a standardized level of 85 candelas/ mm. This self-calibration ensures consistent results from visit to visit. This subjective test measures the patient's ability to detect a difference in luminance (i.e., contrast) between a sine-wave grating and its background.

Contrast can vary from a minimum of zero to a maximum of

one. Typically, the response of interest is the observer's contrast threshold, which is the minimum amount of contrast needed to detect the presence of the patterned stimulus. Contrast thresholds are measured for gratings of various spatial frequencies. The reciprocal of contrast threshold is referred to as contrast sensitivity^[3].

At each testing session, contrast sensitivity was measured for four spatial frequencies: 3, 6, 12, and 18 cycles/degree (cpd). The CSV-I000E is operated by wireless remote control. Each section of the test is individually performed and can be isolated for testing. The key to sensitivity of a contrast test is uniform contrast change across test targets. The CSV-1000 E uses equal logarithmic step sizes of 40% change between adjacent contrast Targets.

All patients were tested with best spectacle-corrected visual acuity. The distance between the patient and the unit was 2.1 meter. The patient was asked to identify the sine-wave gratings for each patient frequency until he or she failed to recognize the grating; the last recognized was the contrast threshold level. The four spatial frequency tests for each eye took 40 seconds or less. All contrast sensitivity examinations were performed by the same examiner.

The mean of the contrast sensitivities was calculated; the paired Student's *t*-test was used for statistical analysis of the whole group. Differences were considered statistically significant when *P*<0.05.

RESULTS

All patients (41 eyes) were available at each postoperative follow-up. Mean postoperative refraction was +1.5 to 1.0D (range +0.1 to+2.31D) at 1 month, +0.71 to 0.90D (range -0.65 to+2.02D) at 3 months, and +0.33 to 0.50D(range -1.0 to +1.4D) at 6 months. Six months after surgery, 61 eyes (74.4%) had no change in best-corrected visual acuity, 10 eyes (12.2%) gained 1 line, 6 eyes (7.3%) gained 2 lines, and 5 eyes (6.1%) lost 1 line.

Table 1 shows the mean preoperative and postoperative contrast sensitivity values, standard deviations, and pair *t*-test analysis to compare these values versus preoperation. Contrast sensitivity decreased significantly at all spatial

frequencies 1 week and 1 month after surgery(Figure 1A,B). There were no statistically significant differences between the preoperative and the third month postoperative values at low spatial frequencies (3cpd). Therefore, the contrast sensitivity values returned to preoperative values at low spatial frequencies 3 months after surgery. However, at intermediate and high spatial frequencies their differences were significant after 3 months (Figure 1C).

Six months postoperatively, the contrast sensitivity values were not different from the preoperative values at 3, 6, and 18cpd. Therefore, the contrast sensitivity values returned to preoperative values at 3,6, and 18cpd spatial frequencies 6 months after surgery (Figure 1D).

DISCUSSION

Visual performance after PRK is commonly evaluated by uncorrected visual acuity, best-corrected visual acuity, and number of Snellen acuity lines gained or lost. However, Snellen visual acuity measurements are of limited value and do not describe visual performance for a variety of spatial frequencies and contrasts [3]. Contrast sensitivity testing expands on the information gained from Snellen acuity testing by determining the resolving power of the eye over a spectrum of target sizes. In this respect, contrast sensitivity testing is analogous to audiometry, in which hearing is evaluated using tones at multiple frequencies rather than at a single pitch[4]. Contrast sensitivity testing maps the resolving sensitivity of the eye over a much broader area than Snellen acuity testing, which represents only the high-contrast end of the contrast curve[5].

Other possible causes discussed include spherical aberration of the abnormal corneal topography [6], decentration, and the effect of the optical junction between the ablated and the non-treated corneal area on large pupils. This last point gains in importance for small ablated zones. The diameter of the ablation zone used in our study was between 5 and 7 mm, with a transition zone of 1-2mm (TTZ). It will be interesting to see if larger ablation zones have a beneficial effect on the outcome, particularly for the high myopes of group III. This will be the focus of our next investigation[7].

Contrast sensitivity after PRK has been studied by many authors [8-17]. Esente *et al* [18] used the VCTS-6000 in two groups of patients: Group A(<-6.0D) and Group B (>-6.0D). In Group A, the value of contrast sensitivity returned to preoperative levels 3 months after surgery. In Group B, the mean contrast sensitivity values of highest frequencies (12 and 18cpd) were below normal 3 months after PRK and returned to baseline levels at 6 months. The reduction in contrast sensitivity at 3 months was correlated with the amount of corneal haze. Pallikaris *et al* [19] used the CSV-1000 test to evaluate contrast sensitivity after PRK to

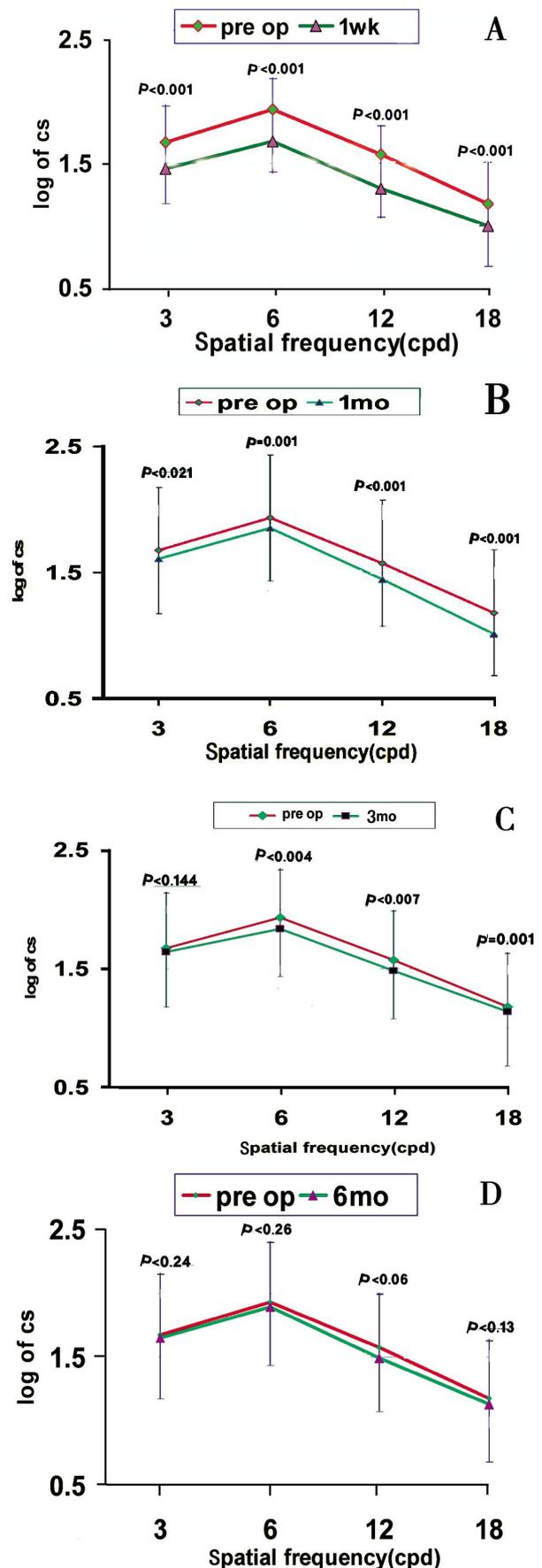


Figure 1 Contrast sensitivity at 3, 6, 12, and 18cpd preoperatively and 1wk (A), 1 (B), 3 (C), 6 (D)mo after PRK (*P* values show postoperative vs preoperative ones)

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correct myopia between 1.0 and 6.0D. They found that contrast sensitivity was reduced 1 month after surgery but returned to preoperative values at 3 months.

Our study showed a decrease in contrast sensitivity at all spatial frequencies 1 week and 1 month after PRK, although contrast sensitivity returned to preoperative values at 3 months at low spatial frequencies. Six months after surgery, contrast sensitivity returned to normal at 3, 6, and 18cpd.

What is the cause of the contrast sensitivity loss? The simplest answer would be the haze. A thorough analysis shows that it can be, at most, an additional factor. It has demonstrated [20-22] that haze increases between the first and third month after PRK. On the other hand, visual acuity already increases between the first and third month, regardless of whether it is measured with 96% or 10% contrast charts, with or without glare. This statement is supported by the lack of correlation between haze and Snellen visual acuity [20], and the weak correlation between haze and low contrast visual acuity with or without glare.

Morphological changes in the cornea, such as haze, can cause incoming light to be back scattered, making the haze visible to the observer. Part of the incoming light is also scattered to the retina (forward scatter). This light causes a deterioration of the retinal image, a reduction of the contrast sensitivity, and a possible increase in glare sensitivity^[7].

The present study had some limitations. Most patients had low myopia or myopic astigmatism. The risk of decreased contrast sensitivity is anticipated with higher levels of preoperative refractive error. Although the number of our cases was significant, larger studies are necessary to confirm findings, and it's recommended to compare these findings with those in patients of low, moderate and high myopia.

In summary, our preliminary results showed that contrast sensitivity decreased 1 month after PRK, although it returned to preoperative levels at 3 months after surgery. This deterioration of vision, which most patients do not notice, needs to be discussed with the patient and has to be taken into consideration when patients counseled for excimer surgery, since it may be of importance in certain circumstances (professional, driving, later onset of other pathological conditions). Further evaluation of contrast sensitivity testing after PRK is needed to corroborate our findings.

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