ORIGINAL ARTICLE

EFFECT OF PHOTOREFRACTIVE KERATECTOMY AND LASER IN SITU KERATOMILEUSIS IN HIGH MYOPIA ON logMAR VISUAL ACUITY AND CONTRAST SENSITIVITY

Hana Langrová[1], Matthias Derse[2], Dagmar Hejcmanová[1], Alena Feuermannová[1], Pavel Rozsíval[1], Markéta Hejcmanová[3]

University Hospital in Hradec Králové: Department of Ophtalmology[1]; University Hospital, Tübingen: Department of Ophtalmology[2]; University Hospital, Bohunice, Brno: Department of Ophtalmology[3]

Summary: Purpose: To compare effect of photorefractive keratectomy (PRK) and laser in situ keratomileusis (LASIK) on contrast sensitivity (CS) and best corrected visual acuity (BCVA) in high myopia. Methods: 38 myopes (PRK) and 31 patients (LASIK) were examined before and 1, 3, 6, and 12 months postoperatively. Mean preoperative spherical equivalent was -8.0 ± 1.7D (PRK) and -9.2 ± 2.1D (LASIK). CS was tested on a computerized system of the Contrast Sensitivity 8010 Type at 6 spatial frequencies (0.74 and 29.55 c/deg), BCVA was measured on logMAR charts. Results: At 12 months postoperatively, mean spherical equivalent was -0.6 ± 1.0D (PRK) and -1.0 ± 0.8D (LASIK). Postoperative values of CS were significantly higher in the PRK group, except for spatial frequencies of 3.69 and 7.39 c/deg up to 3 months postoperatively. The initial significant decrease of BCVA lasted up to 6 months after PRK. In the LASIK group BCVA was not significantly different from its preoperative level at the 3-months follow-up. Conclusions: The significant improvement of CS after PRK suggest that PRK can improve quality of vision in eyes with high myopia. Although recovery of BCVA after LASIK was faster than after PRK, there may be a persistent decrease in CS.

Key words: *PRK; LASIK; High myopia; logMAR charts; Contrast sensitivity*

Introduction

Although a number of studies have been published reporting on the results of excimer photorefractive keratectomy (PRK) and laser in situ keratomileusis (LASIK), only few direct comparisons of PRK and LASIK are available. Moreover many studies (1,5,6,17) evaluate the uncorrected visual acuity (UCVA), the best corrected visual acuity (BCVA), the number of Snellen acuity lines gained or lost, and the manifest refraction, which do not enable the detection of subtle changes of postoperative visual functions like reduced night vision and contrast or increased glare. More precise methods, e.g. contrast sensitivity (CS) and glare testing, or examination of threshold on logMAR (logarithm of minimum angle of resolution) charts can provide a better comparison of the advantages and potential risks of both types of refractive surgery. The aim of our study was to compare the quality of vision in patients with myopia above -6.0 D after PRK and LASIK, based on CS and logMAR BCVA testing.

Patients and Methods

Laser treatment was performed using the Multiscan excimer laser system (Schwind, Germany) (3). All patients were treated by two surgeons (P. R., A. F.). Laser parameters included a wavelength of 193 nm, pulse duration of 23 ns, fluence at the corneal plane of 230 mJ/cm^2 and a repetition rate of 13 Hz. The treatment zone diameter was 6.0- or 6.5-mm. For the LASIK procedure, the Mikrokeratom (Schwind, Germany) or the Supratome (Schwind, Germany) were used to prepare a corneal flap of 8.5-mm diameter and 160-μm thickness. Thirty-eight eyes of 38 myopes (23 female, 15 male) with a mean age of 25 years (range 18 to 48 years) were treated by PRK procedure for myopia between -6.0 D and -12.0 D. The astigmatism was up to -4.0 D (mean spherical equivalent -8.0 ± 1.7 D, range -6.0 to -12.6 D). Thirty-one eyes of 31 patients (20 female, 11 male) with a mean age of 24 years (range 19 to 48 years) were treated by the LASIK procedure for myopia ranging between -6.0 D and -13.0 D. The astigmatism was up to -4.0 D (mean spherical equivalent -9.3 ± 2.1 D, range -6.0 to -14.0 D). 20 healthy eyes of 16 women and 4 men (mean age: 26 years, range 20 to 40 years) with no potential relevant eye disease and UCVA of 20/30 or better (Snellen acuity) were examined as a control group. Informed consent was obtained from all subjects. This study was reviewed by an ethic committee. The patients were examined before surgery and at 1, 3, 6 and 12 months postoperatively. The preoperative as well as all follow-up visits included a detailed ophthalmologic examination with measurements of BCVA, manifest refraction and CS testing. BCVA was measured under controlled lighting conditions using optotype logMAR charts. The CS was tested using a computerized Contrast Sensitivity 8010 System (Neuroscientific Corp., Farmingdale, USA). The mean CS was calculated and the paired Student's t-test was used for statistical analysis. Differences were considered statistically significant when P-values were less than 0.05. The distance for examination of threshold BCVA on logMAR charts was 4 meters. Each of the 14 rows for visual acuity between 0.1 (20/200) and 2.0 (20/10) contained 10 Landolt rings. Their size in the subsequent rows had a logarithmic progression. The change of about one line on the logMAR charts represented a change in BCVA of about 26 %. It was possible to detect a change of BCVA even of about 1 optotype (10,14). The number of correct answers was noted and the method of Ferris et al. (8) was used for the calculation of the threshold. The distance for CS measurement was 2.2 m so that a range of spatial frequencies from 0.74 to 29.55 c/deg was achieved. The size of the monitor appeared as 5 deg x 3.5 deg in the center of the visual field. CS was measured by the method of ascending and descending limits for six spatial frequencies: two low (0.74; 1.97 c/deg), two intermediate (3.69; 7.39 c/deg) and two high frequencies (14.77 and 29.55 c/deg) (9).

Results

Visual acuity

The preoperative and all postoperative values of BCVA in patients were significantly lower compared to controls ($P < 0.001$). Preoperative BCVA in PRK group was significantly higher than in LASIK group ($P = 0.0002$). At the 1-month follow-up BCVA decreased significantly in both groups ($P = 0.00007$ for the PRK group and $P = 0.01$ for the LASIK group). The decrease of BCVA lasted up to 6 months

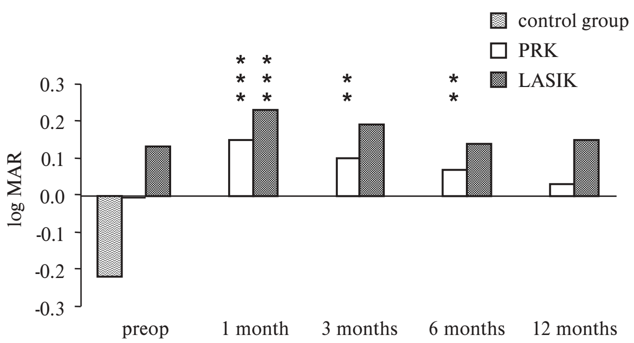

Fig. 1: Mean threshold BCVA (logMAR) of a control group and myopes undergoing PRK and LASIK. Three stars represent a significance at a level of 0.001 and two stars represent a significance at a level of 0.01 between logMAR of myopes after surgery and its preoperative values of the same group.

after PRK but the difference from its preoperative level was not significant at 12 months postoperatively. In contrast in the LASIK group, BCVA improved faster and was not significantly different from its preoperative level at the 3 months and for the entire follow-up. BCVA at the 1- and 3-month follow-ups were not significantly different between both groups, thereafter values of BCVA were significantly higher in PRK group than in the LASIK one ($P = 0.04$ and 0.0005, resp.) (Fig. 1). At 12 months postoperatively, improvement of BCVA was measured in 51.5 % (PRK) and 51.8 % (LASIK) patients about 1 optotype up to 2.5 lines (equal to 25 optotypes). Four patients of the PRK group lost 2 and 3 lines in BCVA due to significant corneal haze after corrections of -9.25 D to -12.0 D. A detailed evaluation of BCVA changes at 12 months after surgery in lines is documented in Tab. 1 and 2.

Tab. 1: Percentage of eyes with gain of BCVA at 12 months postoperatively in lines.

Lines gained	n	0	1	2	3
PRK	35	8.6	34.3	8.6	0.0
LASIK	31	13.0	32.4	6.4	3.1

Tab. 2: Percentage of eyes with decrease of BCVA at 12 months postoperatively in lines.

Lines gained	n	1	2	3
PRK	35	25.7	11.4	11.4
LASIK	31	29.0	16.1	0.0

Refraction

The mean preoperative manifest spherical equivalent in the PRK group was -8.0 ± 1.7 D and in the LASIK group -9.2 ± 2.1 D. The mean manifest spherical equivalent at 12 months postoperatively were -0.6 ± 1.0 D in the PRK group and -1.0 ± 0.8 D in the LASIK one. At 1 month, a significantly higher number of eyes in the PRK group were within ± 0.5 D of emmetropia compared with the LASIK group. In contrast, at 6 and 12 months postoperatively, a significantly higher number of eyes in the LASIK group were within ± 0.5 D of emmetropia (58.1 % (LASIK) in comparison with 31.4 % (PRK) at 12 months). A residual refraction of ± 1.0 and ± 2.0 D was comparable in both groups at all times (Tab. 3). In both groups, 5.8 % of eyes showed per-

Tab. 3: Percentage of eyes with a manifest refraction of ± 0.5 D; ± 1.0 D and ± 2.0 D at 12 months postoperatively.

time after surgery	surgery	n	±0.5	±1	±2
1 month	PRK	38	73.7	81.6	100.0
	LASIK	28	50.0	71.4	100.0
3 months	PRK	36	50.0	77.8	100.0
	LASIK	28	53.6	75.0	100.0
6 months	PRK	35	45.7	74.3	100.0
	LASIK	29	58.6	75.9	100.0
12 months	PRK	35	31.4	74.3	100.0
	LASIK	31	58.1	80.7	100.0

sistent hyperopia ranging from +0.5 to +1.0 D (mean +0.75 D). A higher percentage of eyes were retreated with PRK (3 retreated eyes; 7.5 %), than with LASIK (no retreated eye). Reoperations were performed for undercorrection between -1.25 D and -3.25 D with no loss of BCVA prior to retreatment.

Contrast sensitivity

The CS of all myopes before and after surgery was significantly lower compared to the controls ($P < 0.05$ to $P < 0.001$) with no significant differences at the lowest spatial frequency in all terms in the PRK group. Preoperatively, there were no significant differences between the PRK and LASIK groups. On the other hand, postoperative data of CS were significantly better in the PRK group ($P < 0.05$ to $P < 0.001$) with the exception of nonsignificant differences at intermediate spatial frequencies at 1 and 3 months postoperatively. In the PRK group, there were no significant changes in CS up to 3 months postoperatively with the exception of a significant increase in CS at the highest frequency ($P = 0.04$ and $P = 0.004$ resp.). Six months after surgery, CS increased significantly at intermediate and high spatial frequencies ($P < 0.05$ to $P < 0.001$). At 12 months after PRK, CS was found to be 99.4 %, 102 %, 105 %, 109 %, 115 %, and 140 % respectively of its preoperative values for the 6 spatial frequencies. On the other hand, in the LASIK group, CS decreased significantly at all spatial frequencies at 1 month postoperatively ($P < 0.05$ to $P < 0.001$). At spatial frequencies of 1.97 and 3.69 c/deg CS remained significantly lower up to 12 months ($P < 0.05$ and $P < 0.01$). At all other spatial frequencies CS increased, but was not significantly lower compared to its preoperative data. 12 months after LASIK, CS reached 96 %, 95.8 %, 96.3 %, 95.8 %, 97.8 %, and 94.6 % respectively of its preoperative values at the 6 spatial frequencies (Fig. 2, Tab. 4 and 5). Typical postoperative changes in CS at spatial frequency of 14.77 c/deg after PRK and LASIK are shown on Fig. 3.

Tab. 4: CS changes after PRK: ↑ represent significant improvement ($P < 0.05$).

Follow up	c/deg 0.74	1.97	3.69	7.39	14.77	29.55
1 month						↑
3 months						↑
6 months			↑	↑	↑	↑
12 months			↑	↑	↑	↑

Tab. 5: CS changes after LASIK: ↓ represent significant decrease ($P < 0.05$).

Follow up	c/deg 0.74	1.97	3.69	7.39	14.77	29.55
1 month	↓	↓	↓	↓		↓
3 months	↓	↓	↓			
6 months			↓			
12 months		↓	↓			

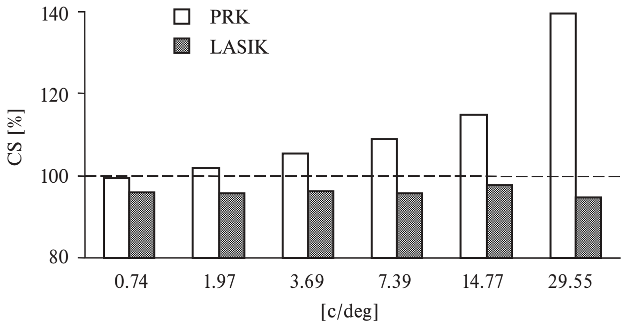

Fig. 2: Contrast sensitivity (%) at 12 months after PRK and LASIK in according to its preoperative values, which represents 100%.

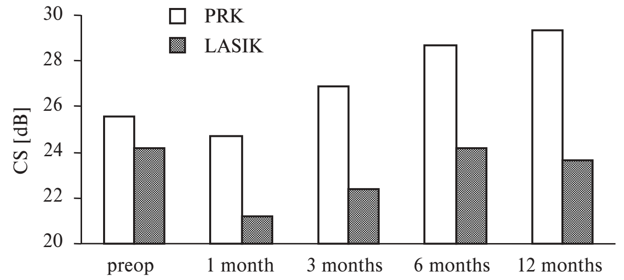

Fig. 3: Typical course of postoperative contrast sensitivity (dB) after PRK and LASIK at the spatial frequency of 14.77 c/deg.

Discussion

In our study, preoperative BCVA was significantly higher in the PRK group compared to the LASIK one, due to the higher myopia in this group. No significant differencies in preoperative CS were found between both groups. Postoperatively, BCVA recovered within 3 months in the LASIK group, whereas in the PRK group there was no significant difference at 6 and 12 months. The decrease of BCVA at 1 month was significantly higher after PRK than LASIK. At the 6- and 12-month follow up, BCVA was significantly higher in PRK group. This is not consistent with finding of Pop et al. (17) who described no statistical differencies in BCVA, refraction and regression for 107 eyes (PRK) and 107 eyes (LASIK) at 6- and 12-months follow ups, even though those groups were greater. The number of over-corrected eyes in both groups (5.8 %) at 12 months postoperatively in our study was higher than that by Pop et al. (17), who reported 3.7 % (PRK) and 1.3 % (LASIK). On the other hand, our higher incidence of reoperations after PRK (7.5 %) than after LASIK (0 %) was lower than those reported by Pop et al. (17) (9.3 % PRK and 2.8 % LASIK reoperations for undercorrection between -1.0 to -2.75 D). Helmy et al. (5) found that regression of the corrective effect was common in both the PRK and LASIK groups, starting between 3 and 6 months after surgery and continuing for up to 1 year. In our study, at the 12-months follow up, 74.3 % of eyes in the PRK group, compared with 80.7 % of eyes in the LASIK group, were within ± 1.0 D of the desired correction. Only 31.4 % of eyes in the PRK group and 58.1 % in the LASIK group were within ± 0.5 D. These findings are similar to those of Helmy et al. (2). The 6 months results of our study are between the once reported by Hersh et al. (6) (29.4 % of PRK eyes and 27.1 % of LASIK eyes within ± 0.5 D) and the results of Pop et al. (17) (82.0 % of PRK eyes and 71.7 % of LASIK eyes).

Our study showed a decrease in CS at all spatial frequencies up to 3 months in the LASIK group, which corresponded with a decrease of BCVA in the same period of time. Both recovered mainly to the preoperative level. In spite of an even greater decrease of BCVA in the PRK group, CS remained at the preoperative level at 1 month, thereafter CS values increased above the initial level at all spatial frequencies. Postoperative CS was mostly significantly higher in the PRK group than in the LASIK one. The improvement of postoperative CS could be partially caused by a positive learning curve of the patients by repeated examinations as mentioned by Woods and Thompson (20). Pérez-Santonja et al. (15) also described a decrease of CS at low and intermediate spatial frequencies (3 and 6 c/deg) at 1 month after LASIK in 14 eyes with myopia between -6.0 and -19.5 D using the CSV-1000E contrast sensitivity unit (Vector Vision). This drop was followed by a recovery to the preoperative data at 3 months, which is in contrast to our findings. The same authors (15) found a nonsignificant improvement at spatial frequencies of 3, 12 and 18 c/deg at 6 months postoperatively. Nakamura et al. (12) found in myopes with more than -6.0 D a decrease in the 15 % and 2.5 % contrast levels (Contrast-Visual-Acuity-Charts) up to 3 months after LASIK. Mutyala et al. (11) described a significant decrease of CS only at 18 c/deg at 1 week and at 12 c/deg 3 months after LASIK. Holladay et al. (7) found a decrease of contrast threshold in 7 patients, which improved slightly but had not returned to baseline by 6 months after LASIK. The authors (7) supposed that the oblate shape of the cornea following LASIK is the predominant factor in the functional vision decrease. Knorz et al. (8) stated that LASIK seems to cause a reduction of mesopic vision under glare conditions in corrections of more than -5.0 D and in addition that mesopic vision is reduced in myopia over -10.0 D even preoperatively, which is corresponding to our findings. Similar to us Niesen et al. (13) found improvement of CS at 12 months after PRK for spatial frequencies of 12 and 18 c/deg using MCT 6500 in 32 patients with myopia between -2.75 D to -13.63 D. But the majority of authors described only nonsignificant changes of CS after PRK (4,16,18,19) in high myopia.

Further evaluation of larger cohorts is needed to corroborate our findings of visual functions after PRK and LASIK.

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MUDr. Hana Langrová, Ph.D.,
University Hospital in Hradec Králové,
Department of Ophtalmology,
Sokolská 158, 500 05 Hradec Králové,
Czech Republic.
e-mail: langrovah@lfhk.cuni.cz