Heterophoria and Fusional Reserves Changes after Photorefractive Keratectomy for Myopia

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Abstract

Purpose: The goal of this study was to compare differences in the mean heterophoria and fusional amplitudes before and after photorefractive keratectomy (PRK) for myopia.

Methods: In a prospective controlled study, myopic patients were treated with aspheric and wavefront-guided (personalized) PRK. The manifest refraction, visual acuity, fusional amplitudes and heterophoria were evaluated preoperatively and at three and six months postoperatively. Fusional amplitudes were measured at far (six meters) and near (40 centimeters) by rotary prism and heterophoria was evaluated at nearby Maddox wing.

Results: A total of 48 cases (96 eyes, 68.75% female) were treated, with a mean age of 26.70±4.89 years (18-34 years). In the fusional reserves, comparisons between preoperative and six months postoperative means showed that far and near convergence reserves (or base out recovery points) and near divergence (or base in recovery point) were decreased significantly (p-values were 0.013, 0.002 and 0.008, respectively). In heterophoria measurements, contrary to the rest of the deviations, exophoria was increased, but not significantly (p=0.063).

Conclusion: Findings of this study imply that far and near convergence amplitude (or base out reserves) were decreased significantly after keratorefractive surgery (KRS). The other fusional reserves were similarly decreased at three months postoperatively and returned to the preoperative values at six months.

Keywords: Fusional Amplitude, Photorefractive Keratectomy, Myopia

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Introduction

Keratorefractive surgery (KRS) has become a common procedure for the correction of refractive errors.[1] In technology-assessment reviews of the safety and efficacy of refractive surgery, monocular visual outcome without spectacle correction is the reference for success. However, these procedures entail certain complications such as binocular diplopia, which may occur in patients with no history of strabismus and persist for a long time.[2-8] These complications, aware the ophthalmologists to include an orthoptic examination including fusion potential and heterophoria in the preoperative evaluation and to define patients at risk. In this study, we aimed to compare differences in the mean heterophoria and fusional vergences values before and after photorefractive keratectomy (PRK) for myopia.

Methods

Patients with myopia and myopic astigmatism who presented to our center (Khatam-al-Anbia Eye Hospital, Mashhad, Iran) for refractive surgery from January to September 2010 were enrolled in this study. Inclusion criteria were age between 18 and 35 years, spherical equivalent refraction between -1.00 and -7.00 diopters (D) with astigmatic error ≤3.00 D, and stable refraction for at least one year. Exclusion criteria included all issues regarding refractive surgery like the presence of any ocular pathologic condition impairing visual function and presence of systemic disorders including diabetes mellitus, collagen vascular and autoimmune diseases and also women with pregnancy and breastfeeding or issues regarding hetrophoria measurements like any manifest strabismus (hetrotropia). Patients with central corneal thickness <490 µm, calculated residual thickness <400 µm, and high-order wavefront root mean square (RMS) error >0.50 µm in the 6 mm optical zone were also excluded. All patients discontinued contact lens wearing at least one month before topographic and aberrometric evaluation.

All patients underwent PRK in both eyes. This study was registered with the Ethics Committee of Mashhad University of Medical Sciences and clearance was obtained. Written informed consent was obtained from all participants.

Examinations

Before surgery, a detailed ocular examination was performed, including manifest refraction, slit scan corneal elevation topography (OrbscanIIz, Bausch & Lomb, Rochester, NY), slit-lamp inspection of the anterior and posterior segments of the eyes, and funduscopy. The uncorrected and best corrected visual acuity (UCVA and BCVA, respectively) were tested with the standard Snellen chart.

Heterophoria was measured subjectively by Maddox wings and fusional amplitudes by rotary prism. All the tests were done between 9 to 11 o'clock in the morning to reduce the effect of daytime and fatigue on measurements. We excluded heterotropia by cover-uncover test at far and near. Then the Maddox wing was used to subjectively record the presence of any heterophoria at near. For this reason, Maddox was held by the individual and he was asked to fix the black and red flashes on the Maddox. Then the person read the number faced on each flash. Also the movement directions of flashes were reported (left or right for red flash and up or down for black one). In this way, the examiner could achieve the amount of eso or exo and hyper or hypo phoria, according to the explanation on Maddox. Cyclophoria was also evaluated by asking the individual to look at the movable needle on Maddox.[9] On the other hand, far and near fusional reserves at six meters and 40 centimeters were measured by rotary prism before refractive surgery while the patient wears best corrective glass. The rotary prism with base in direction (to evaluate divergence reserve) was put in front of the dominant eye of the patient and he was asked to fix at Snellen chart, two lines above his BCVA at six meters. The patient was asked to declare when the target gets doubled with change of prism power (break point) and again singled (recovery point). Then the base out prism was slowly rotated laterally to evaluate convergence reserve, so break and recovery points were assessed. In addition to four defined points (break and recovery points with base out and base in prism) blur point were also recorded at near distance (40 cm). We considered the break points as fusional vergence amplitudes in our study. These investigations were repeated three and six months after KRS. All measurements were done by the same trained optometrist.

Refractive surgical technique:

Two surgeons (S.Z.G and H.G) performed all surgeries using a flying-spot excimer laser (Technolas 217z, Bausch & Lomb, Rochester, NY) with an emission wavelength of 193 nm, a fixed pulse repetition rate of 100 Hz, and a radiant exposure of 400 mJ. Tracking system applied in these patients was Bausch & Lomb Advanced Control Eyetracking (ACE) (Bausch & Lomb, Rochester, NY). Photoablation was performed using wavefront-guided personalized ablation PRK algorithm software using aberrometry findings from the Zywave aberrometer incorporated into the excimer laser system by Zylink system (version 2.3, Bausch & Lomb) or aspheric treatment was performed with aspheric algorithm software using OrbscanIIz incorporated.

In all patients, a sponge soaked with mitomycin-C 0.02% was placed over the ablated area for five seconds per each diopter of treatment. This was followed by copious irrigation with a balanced salt solution and bandage contact lens fitting.

Postoperative evaluations

Postoperative examinations were scheduled for one, three, seven, and 30 days and one, three and six months after surgery. At three and six postoperative months, BCVA, UCVA, refraction, heterophoria and fusional vergences were evaluated.

Statistical analysis

Statistical testing was performed with SPSS Windows version 16 (SPSS, Inc., Chicago, IL). The variables are reported as the mean±standard deviation (SD). All of the available data were evaluated by Kolmogorov-Smirnov test and were in normal distribution. Analysis of variance (ANOVA) with Repeated Measures was performed to test the difference between the measurements before and postoperation for each patient. Differences with $p<0.05$ were considered statistically significant.

Results

Forty eight patients (15 male and 33 female) with a mean age of 26.78±4.89 years (19 to 38 yrs) were included. The visions and refractive outcomes are summarized in table 1. All tested data had normal distribution according to the Kolmogorov-Smirnov test results. Improvement was noted after surgery in the mean refractive error, and UCVA. The manifest refractions decreased significantly after PRK. Although the patients were mildly myopic (-0.168±0.031 D) in the six month's follow-up, the mean UCVA improved from 0.857 to 0.002 logMAR ($p<0.001$). Six months after surgery, the mean BCVA was 0.004±0.002.

In the fusional reserves, comparisons between preoperative and six months postoperative means showed that far and near convergence reserves (or base out recovery points) and near divergence (or base in recovery point) were decreased significantly (p values were 0.013, 0.002 and 0.008, respectively). Moreover, near base out break point was also decreased. In heterophoria measurements, contrary to the rest of the deviations, exophoria was increased ($p=0.063$). Table 2 summarizes the heterophoria and fusional reserves before the operation and three and six months after surgery.

Table 1. Pre- and postoperative measurements

	Preoperative (Confidence interval)	Three months postoperative	Six months postoperative	p (c)
Spherical refractive error	-3.285±0.191 (-3.665 to -2.905)	-0.003±0.031 (-0.066 to 0.059)	-0.076±0.029 (-0.135 to -0.018)	<0.001
Cylinder	-0.563±0.069 (-0.7 to -0.425)	-0.236±0.032 (-0.3 to -0.172)	-0.184±0.028 (-0.239 to -0.129)	<0.001
Spherical Equivalent	-3.566±0.184 (-3.934 to -3.198)	-0.122±0.033 (-0.187 to -0.056)	-0.168±0.031 (-0.230 to -0.107)	<0.001
Uncorrected visual acuity	0.857±0.064 (0.730 to 0.985)	0.002±0.001 (-0.001 to 0.005)	0.002±0.001 (-0.001 to 0.005)	<0.001
Best corrected visual acuity	0.0±0.0 (0 to 0)	0.001±0.001 (-0.001 to 0.003)	0.001±0.001 (-0.001 to 0.003)	0.06

Table 2. Heterophoria and fusional reserves pre- and postoperation

	Preoperative (range)	Three months postoperative (range)	Six months postoperative (range)	
Exophoria (PD)	1.911±2.999 (0-13)	2.067±2.824 (0-8)	2.698±2.891 (0-8)	0.057
Esophoria (PD)	0.234±0.914 (0-4)	0.000±0.0 (0-0)	0.000±0.0 (0-0)	0.057
Hyperphoria (PD)	0.104±0.472 (0-3)	0.000±0.0 (0-0)	0.000±0.0 (0-0)	0.133
Far Base In Break Point	13.306±4.682 (6-26)	14.972±4.996 (6-22)	13.083±5.511 (3-23)	0.643
Far Base In Recovery Point (divergence)	5.875±3.304 (3-19)	8.588±2.769 (3-12)	6.878±1.962 (2-9)	0.527
Near Base In Break Point	20.102±7.702 (6-30)	20.205±6.784 (5-28)	19.125±6.529 (3-28)	0.982
Near Base In Recovery Point (divergence)	14.575±6.783 (3-30)	11.666±4.280 (3-18)	11.941±4.183 (3-22)	0.008
Far Base Out Break Point	16.833±8.177 (5-30)	13.896±6.229 (6-21)	16.437±6.693 (3-30)	0.127
Far Base Out Recovery Point (convergence)	9.666±4.593 (3-30)	5.785±2.520 (3-15)	6.758±3.462 (3-12)	0.013
Near Base Out Break Point	17.485±7.124 (3-30)	13.913±6.208 (2-24)	14.826±6.197 (3-29)	0.009
Near Base Out Recovery Point (convergence)	10.843±7.961 (3-30)	6.166±3.516 (0-15)	6.904±4.723 (3-22)	0.002

Discussion

In this study, we evaluated ocular heterophoria and fusional vergences values in myopic patients treated by PRK. PRK were performed for patients with myopia less than -7.00 diopters, all patients were without preoperative deviation. The procedure was safe and significantly improved postoperative UCVA.

In evaluations of heterophoria, there were no significant changes in esophoric and hyperphoric deviations. But exophoria was increased although it wasn't very significant. We found no new deviation introduced. The changes in phoric deviations may be due to treatment of myopia and patients need for convergence. The patients in near vision, needs more accommodation and convergence, and were adapted to their conditions.

None of our patients developed diplopia after PRK. Several different mechanisms may result in strabismus and diplopia in patients with anisometropia, especially aniseikonia.[6] In our patients, we considered correcting low to moderate myopia, and therefore, it is logical not to have diplopia or induced diplopia.

Regarding fusional reserves, we found that far and near base out recovery points (fusional convergence) far base out recovery (fusional divergence) were decreased significantly and also remained so after six months. In other forms of fusional reserves, an early decrement was seen during three months which increased after six months of follow-up and in most reached items, recurs to the preoperative values. Based on the result of heterophoric changes that the patients may acquire after KRS, problems in convergence are inevitable.

Few studies evaluated the orthoptic changes after refractive surgeries. Rajavi et al have evaluated orthoptic changes after PRK. They found that PRK neither improved nor induced eso- or exodeviation, 4% of patients showed improvement and 4% developed new deviations. Decrease in convergence and divergence amplitudes were detected in 6.6% and 3.3% of patients, respectively. They showed that only reduction in convergence amplitude may result in exodeviation. Other significant result of the study was increasing of near point of convergence (NPC). No patient developed diplopia postoperatively.[8]

Hashemi et al have reported that NPC and near point of accommodation were increased significantly after PRK and concluded that convergence and accommodation problems may affect near visual performances.[10] Godts et al evaluated five patients with history of strabismus surgery which had subjective problems after Keratorefractive procedure. They have found an overcorrection or undercorrection in one or both eyes or anisometropia and concluded that in cases who are unhappy with contact lenses, special care and more orthoptic evaluations should be performed before refractive surgery. They have recommended that in each patient with a positive history of strabismus therapy, an orthoptic examination should be done, either with or without glasses.[4]

They have also reported in another study that in low to moderate myopia, laser KRS aiming emmetropic correction is safe enough and does not worsen the patients' condition even in patients with deviation, if an adequate preoperative orthoptic examination has been performed. They reported that in their case series, refractive surgery did not markedly influence ocular alignment.[5]

Kowal proposed risk stratification guidelines in cases of myopia. He proposed that patients with the following characteristics were classified in no risk group and needed no additional orthoptic evaluation: no history of strabismus or diplopia, no or trivial phorias with alternate cover test, and good vision with their glasses confirmed by dry refraction and cycloplegic refraction all within 0.5 D of error.[7]

Conclusion

We can conclude based on this study that performing PRK in cases with low to moderate myopia may have some effect on fusional convergence amplitude and can increase exophoria in susceptible cases.

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