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Original research

Stereoacuity after photorefractive keratectomy in myopia

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Abstract

***Purpose*:** Stereopsis, as a part of visual function, is the ability of differentiating between the two eyes' views (binocular disparity), due to the eyes' different positions. The aim of this study was to compare stereoscopic vision before and after photorefractive keratectomy (PRK) in myopia.

***Methods*:** In a prospective interventional case series study clinical trial, forty-eight myopic individuals (age range: 18–34 years) who had undergone PRK surgery by a Bausch & Lomb Technolas 217z excimer laser were included. In all patients, stereoscopic vision was assessed using TNO test charts at 40 cm distance preoperatively and at 3 and 6 months postoperatively.

***Results*:** A total of 48 cases (96 eyes, 69% female) with a mean age of 26.70 ± 4.89 years (range: 18–34 years) were treated. Uncorrected visual acuity (UCVA) was improved and refraction was corrected significantly after PRK surgery. The stereoscopic vision in patients was 246.56 ± 98.43 s of arc before PRK surgery. Postoperatively, the stereoacuities were recorded as 365.38 ± 112.65 s of arc and 343.51 ± 88.96 s of arc at 3 and 6 months, respectively. These differences were statistically significant ($p < 0.001$).

***Conclusion*:** PRK was successful and safe in improving refractive error and UCVA, but it may deteriorate the stereoscopic vision. It may be due to an increase in higher order aberrations.

Keywords: Stereoscopic vision; Photorefractive keratectomy; Myopia

Introduction

Stereopsis, as one of the visual functions, is the ability to differentiate between the two eyes' views (binocular disparity), due to the eyes' different positions on the head.[1,2] Binocular disparity provides information that the brain can use to perceive depth in order to form a three-dimensional percept.[3,4] Stereopsis is testable in the clinic and has often been employed as the stand-alone measure of depth perception.

Photorefractive keratectomy (PRK), a form of excimer laser photoablation of the cornea, has been performed for the correction of myopia since the 1980s.[5,6] PRK has been shown to be a safe and effective technique in the treatment of mild to moderate myopia, with a relatively high level of satisfaction reported by patients.[7] This technique has a lower incidence of postoperative ectasia and avoids sight-threatening flap complications.[8]

Among several refractive procedures which have been performed worldwide, little emphasis is placed on

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postoperative binocular visual function such as stereoacuity. The purpose of this study was to evaluate the stereoscopic vision before and after PRK surgery in myopia.

Methods

Study population

This prospective interventional case series study was carried on individuals who were referred for keratorefractive surgery with myopia or myopic astigmatism to Khatam-al-Anbia Eye Hospital from March 2009 till March 2010. The sampling method was simple. The pre-operative mean spherical equivalent (MSE) refraction was between −1.00 and −7.00 D with 3.00 D or less cylindrical power. All subjects had stable refraction for at least one year and pre-operative best-corrected visual acuity (BCVA) of 20/20 or better.

Patients with any ocular pathologic condition impairing visual function, corneal dystrophies or abnormalities, ocular alignment diseases, or previous ocular surgery were excluded from the study population. In addition, patients were excluded in case of central corneal thickness less than 470 μm, calculated residual thickness less than 350 μm, and high-order wavefront root mean square (RMS) more than 0.50 μm in 6 mm optical zone. Informed consent was obtained from each participant after the nature of the experimental procedures had been explained. The study was followed the tenets of the Declaration of Helsinki and approved by the Ethics Committee of Mashhad University of Medical Sciences.

Measurements

Before surgery, a detailed ocular examination was performed, including uncorrected visual acuity (UCVA) and BCVA, slit lamp examination, applanation Goldmann tonometry, indirect ophthalmoscopy, manifest and full-cycloplegic refraction, keratometry, and complete topographical evaluation. Stereoacuity measurements were performed using global TNO test charts (stereoscopic acuity test of the Netherlands Organisation for Applied Scientific Research, Lameris Ootech BV, Nieuwegein, The Netherlands), according to the manufacturer's instructions. (TNO test for stereoscopic vision, Eighth Edition, Lameris, The Netherlands) All measurements before and after PRK were performed with BCVA glasses. With the TNO test, the red and green anaglyphic filters were worn, and the booklet was held at 40 cm perpendicular to the subject's visual axis. At first, the screening plates (plates of I, II, III, IV) were shown, and if these were successfully completed, the graded plates from 480 to 15 s of arc were presented until the subject was unable to identify the three-dimensional shape correctly. Finally, the lowest disparity that the subject was able to detect was recorded as his/her stereoacuity in seconds of arc. Stereoacuity was tested by using best corrected visual acuity refraction. The stereoacuity of all the patients were re-examined at three and six months post-operative visit.

Surgical technique

Two surgeons (S.Z.G and H.G) performed all surgeries using a flying-spot excimer laser (Technolas217z, Bausch & Lomb) with an emission wavelength of 193 nm, a fixed pulse repetition rate of 100 Hz, and a radiant exposure of 400 mJ. The tracking system applied in these patients was Bausch & Lomb Advanced Control Eyetracking (ACE) (Bausch & Lomb, Rochester, NY). This system is a dynamic rotational eye tracking system that tracks and simultaneously adjusts the ablation pattern for the entire duration of the treatment.

Antisepsis was performed by applying povidone–iodine 10% solution to the skin of the eyelids and periocular area for 1 min, and the eyes were draped in a sterile manner. Each eye was washed out with 20 cc of a balanced salt solution. Then ethyl alcohol 20% was applied in a 9 mm well for 20 s, and the epithelium was removed.

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) in the personalized group, or aspheric treatment was performed with aspheric algorithm software using Orbscan IIz (Bausch & Lomb, Rochester, NY) incorporated. During the personalized treatment, iris registration was used to compensate for rotational eye movement. The optical zone (OZ) was 5.8 mm or larger (always 1.5 mm larger than the low mesopic pupil).

In all patients, a sponge soaked with 0.02% MMC needs expansion was placed over the ablated area for 5 s per each diopter of myopic treatment. This was followed by copious irrigation with a balanced salt solution. A bandage contact lens (Pure Vision, Bausch & Lomb, Rochester, NY) was placed. Postoperatively, the patients were given chloramphenicol 0.5% and betamethasone 0.1% eye drops every 6 h. After complete re-epithelialization (usually on the fifth day), the bandage contact lens was removed. Chloramphenicol was discontinued after one week. Betamethasone was used for one month, and then fluorometholone 0.1% eye drop was started every 6 h and gradually tapered over 2 months. Preservative-free artificial tears were prescribed frequently in the first month and then tapered based on the ocular surface condition.

Statistical analysis

Statistical analysis was performed using SPSS Windows version 16 (SPSS, Inc., Chicago, IL). Quantities and qualitative variables are reported as the mean ± standard deviation (SD) and percent respectively. Data normality was tested using the Kolmogorov–Smirnov test. Taking into account multiple comparisons Bonferroni adjustment was performed and a P value less than 0.01 were considered significant. Changes in outcome measures after PRK were determined in a paired fashion using Wilcoxon Signed Ranks and Friedman test.

Results

Of the 48 patients who underwent PRK surgery, 15 (31%) were male and 33 (69%) were female. ($P < 0.001$) The mean age of the study population was 26.70 ± 4.89 years (range, 18–34 years). The MSE, UCVA, and BCVA of all subjects before and at both follow-up examinations are summarized in Table 1. As expected, significant improvement was noted after the surgery in the mean refractive error and UCVA.

The manifest refractive errors decreased significantly after PRK. Although patients were mildly myopic (−0.17 ± 0.03 D) in the 6 month's follow-up examination, the mean UCVA improved from 0.86 to 0.002 logMAR ($P < 0.001$). Cylinder as an important factor in stereopsis was decreased significantly after the operation ($P < 0.001$).

The mean of the measured stereopsis threshold with TNO test was recorded as 246.56 ± 183.35 s/arc before PRK surgery. At three and six months follow-up examinations after the surgery, the stereoacuities were 365.38 ± 177.44 s/arc and 343.51 ± 191.05 s/arc, respectively. The above-mentioned results indicate that the level of stereoacuity was decreased after PRK surgery ($P = 0.02$). The difference was significant between preoperative measurement and three months ($P = 0.003$) and six months ($P = 0.002$) but non-significant between three months and six months ($P = 0.658$).

Discussion

The aim of refractive surgeries is to improve uncorrected vision over a wide range of refractive errors. Visual acuity (VA) following refractive surgeries is generally assessed using conventional high contract Snellen chart, and the patient's visual function is inferred from this measurement. However, many patients without any residual refractive errors and in spite of 6/6 high contrast VA have complains of their quality of vision after refractive surgeries. Unfortunately, there is no established objective measure for evaluation of visual function after refractive surgeries. Several psychophysical measures such as contrast sensitivity,[9] disability glare,[10] and low contrast acuity[11] have been employed to investigate the refractive surgeries' outcome, and impaired binocular visual function has been reported.[12]

Stereopsis, as a highest level of binocular vision, is important in enabling precise sensing of position and distance. Measurement of the extent of stereopsis can be used to evaluate the levels of binocular visual function after refractive surgeries because stereopsis is fully acquired when visual function returns to the normal level.[13] Decreased levels of stereoscopic vision can be disturbing even in the presence of excellent VA outcome. Unfortunately, in spite of being an easy clinical procedure, stereoacuity is not routinely measured before and after refractive surgeries.

Results of the present study revealed that myopic patients undergoing PRK surgery have reduced stereoacuity. Previous studies' findings considering stereoscopic vision after refractive surgeries are quite contrary to each other. An investigation that was performed by Phillips et al. in 2004 provided results with better stereopsis after Laser in situ keratomileusis (LASIK).[14] In addition, in another investigation by Razmjoo et al,[15] stereoacuities of 200 patients were evaluated up to three months after the LASIK surgery. This study also found an overall improvement in the level of stereoacuity after the refractive surgery.

On the other hand, consistent with our findings, a study by Godts et al,[12] evaluated binocular function of few patients who had undergone keratorefractive surgery and reported diplopia and decreased stereoacuity. Deterioration of the stereoacuity following refractive surgeries may be due to changes in the level ocular aberrations, corneal opacification, or corneal epithelial irregularities, which needs to be evaluated in further investigations.

Our result (worsening of the stereopsis) is somewhat different from previous studies. It may be due to the limitation of the inclusion criteria. Moreover, different profiles of ablations may induce different results, mostly in higher order aberration results. As we have performed PRK by different profiles in both eyes, it itself may induce binocular differences, mostly in both eyes. Using different devices for evaluating the stereopsis may also cause a difference.

The number of participants in our study was small, and the results would be improved by a larger sample size. Moreover, including patients with severe myopia and hyperopia may improve the results.

In summary, our preliminary results demonstrated that stereoacuity decreased three and six months after PRK surgery. Further evaluation of stereoacuity testing in relation with other parameters such as contrast sensitivity, ocular aberration, and opacification after PRK with longer-term follow-up under a rigorous study protocol is needed to corroborate our findings.

Table 1
Values of Mean Spherical Equivalent (MSE), cylinder refractive error, Uncorrected Visual Acuity (UCVA) and Best Corrected Visual Acuity (BCVA) in logMAR before PRK surgery, three and six months after the surgery.

	Preoperative visit[a]	3-month postoperative visit[a]	6-month postoperative visit[a]	P-value[b]
MSE (D)	−3.57 ± 0.184 (−7.12 to −0.62)	−0.14 ± 0.004 (−1.00 to 0.87)	−0.17 ± 0.03 (−0.62 to 0.50)	<0.001
Cylinder (D)	−0.535 ± 0.097 (−4 to 0)	−0.22 ± 0.03 (−1.00 to 0)	−0.13 ± 0.03 (−1.00 to 0)	<0.001
UCVA	0.86 ± 0.06 (0.30–2.00)	0.03 ± 0.012 (0.00–0.80)	0.002 ± 0.001 (0.00–0.10)	<0.001
BCVA	0.0 ± 0.0 (0.00–0.00)	0.009 ± 0.004 (0.00–0.30)	0.001 ± 0.001 (0.00–0.10)	0.072
Higher Order Aberration 6-mm	0.312 ± 0.012 (0.288–0.335)	0.463 ± 0.024 (0.416–0.510)	0.454 ± 0.021 (0.412–0.495)	<0.001

[a] Data are expressed as mean ± standard deviation (range).
[b] P-value was predicted by Analysis of variance (ANOVA) with repeated measures test.

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