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Research Article

Color Vision in Normal Myopic Eyes and Changes before and after Laser in Situ Keratomileusis

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ABSTRACT

Purpose: To evaluate the characteristics of color vision and relevant factors in normal myopic eyes and to assess changes in color vision before and after Laser in Situ Keratomileusis (LASIK).

Method: Fifty-nine consecutive eyes of 31 patients were prospective valuated in a randomized contralateral-eye study. The color vision was measured with Farnsworth-Mun-sell 100-hue test (FM100 test), and relationships with some optic parameters were analyzed in normal myopic eyes. The difference between postoperative and preoperative was evaluated before and 1 day, 1 week and 1 month after surgery.

Results: For normal eyes, there was positive correlation between Square Root of Total Error Score (Sqrt TES) and intraocular pressures (p = 0.045). Sphere, astigmatism, and visual acuity preoperative showed no correlation with Sqrt TES. The Sqrt TES preoperative of the FM 100 test was 7.89 ± 2.34. After surgery, 1 day Sqrt TES was significant higher than the 1 month postoperative values (p = 0.018, ANOVA test). No significant change in the Sqrt TES was observed at 1 day (8.08 ± 2.47, p = 0.469, paired t test), 1 week (7.76 ± 2.16, p = 0.489, paired t test), or 1 month (7.61 ± 2.75, p = 0.146, paired t test).

Conclusion: Intraocular pressures have significant correlation with Sqrt TES in normal myopic eyes. Little changes were detected by the FM 100 test after Laser in Situ Keratomileusis (LASIK). The temporal changes of the photoreceptor layer of the retina maybe as a resulting of increase of intraocular pressures in LASIK surgery might explain this minimal influence.

Keywords: Myopic; LASIK; Color vision

INTRODUCTION

Over the past years, laser in situ keratomileusis has become a popularity ophthalmic procedure for the correction of refractive error. Although more and more studies have shown on the complications of optical quality of the visual system resulting from this procedure, including ocular aberrations, and the decrease of contrast sensitivity [1], these complications are related to the laser ablation and to the microkeratome used to create the corneal flap during the procedure. Reports of posterior segment complications are less common. Retinal detachment has been reported after LASIK previously [2]. However, little has been reported in the literature regarding the color vision after surgery. We concentrated our study on the color vision.

Visual acuity, which is the spatial resolving capacity of the visual system is the most widely used and most useful single clinical measurement for determining whether a significant abnormal to refractive error. It expresses the angular size of detail that can just be resolved by the observer. The visual acuity is composed of near acuity, contrast sensitivity, visual field, glare sensitivity and color vision. Many studies have focus on wave front aberrations and the effect on the quality of vision after refractive surgery. Whereas, in the LASIK technique, a suction ring is applied, exerting considerable pressure on the pars plana region at the limbus, so that a corneal flap can be made with the microkeratome. We speculate that this pressure may bring about some damage to retinal cone photoreceptors of posterior pole of the eye, and result in the change of color vision.

A few studies of color vision have been performed after corneal refractive surgery, and no significant decrease were observed after LASIK [3]. However, the total resolutions to color were described in their articles. In our study, we evaluated not only the resolutions in normal myopic eyes, the correlations of color vision with other optical parameters, but also the total resolution and the changes in each box of the FM 100 test preoperative and postoperative.

PATIENTS AND METHODS

Subjects

This perspective interventional case series comprised 31 patients (59 eyes) who were scheduled for LASIK at the Tianjin Eye Hospital, Tianjin medical university for myopic correction between June 2013 and July 2013. Twenty-six subjects (59 eyes) with ages ranging from 18 to 48 years (24 ± 6.56 years) underwent myopic LASIK refractive surgery for intended myopic spherical correction that ranged from -2.75 to -12.75D (-6.18 ± 2.08 D). Cylinder range from -0.00 to -3.75D (-0.79 ± 0.89 D). Central Corneal Thickness (CCT) ranged from 503 to 590 μm (545.34 ± 21.18 μm). Intraocular Pressure (IOP) preoperative ranged from 8.7 to 20.8 mmHg (14.73 ± 2.96mmHg). The preoperative examination included Uncorrected Visual Acuity (UCVA) and Best Spectacle Corrected Visual Acuity (BSCVA), manifest and cycloplegic refraction, Intraocular Pressure (IOP), topography, slit lamp microscopy, and dilated indirect funduscopy. The inclusion criteria were scheduled for myopic LASIK, willing to participate in the study, and willing and able to give informed consent. They had a Best Corrected Visual Acuity (BCVA) of 20/20 or better preoperatively and an uncorrected near visual acuity of 20/40 or better postoperatively. They did not have glaucoma or ocular hypertension. Exclusion criteria included a history of corneal trauma or past surgery, viral keratitis, and systemic diseases such as diabetes or connective tissue diseases. Patients who wore contact lenses were instructed not to wear at least 2 weeks. The protocol adhered to the tenets of the Declaration of Helsinki and received approval from an institution review board. Informed consent was obtained from all participants after the nature and possible consequences of taking part were explained.

Surgical technique

The same surgeon performed all procedures, and all surgical procedures were performed with anesthesia preoperatively with oxybuprocaine eye drops. A microkeratome (model M2; Moria SA, Antony, France) was used to create a nasal-hinged, 110-μm flap measuring 9.0mm in diameter. The flap was superiorly reflected and the stromal bed was ablated with an excimer laser system Star S4 IR, VISX Inc Santa Clara CA USA. After photoablation, the flap was replaced on the stromal bed, and the interface was irrigated. An optic zone of 6.0 or 6.5mm with an 8-mm transition zone was applied in all cases.

After surgery, topical 0.3% ofloxacin eye drops for 3 days and combined with 0.1% fluorometholone for 4 month. The fluorometholone was administered as 1 drop four times daily for the first month, three times daily for the second month, twice daily for the third month, and once daily for the last week. Follow-up visits were scheduled for 1 day, 1 week, and 1month postoperatively.

Color vision

Color vision was tested using the Farnsworth-Mun-sell 100-hue test (FM100 test), which is the most sensitivity for both congenital and acquired color defects. It consists of 85 hue caps contained in four separate rocks, in each of which the two end caps are fixed while the others are loose so they can be randomized by the examiner. Test was taken in a dark room under standard illuminants (D65 6500K). The patient is instructed to select a cap that is most like the reference cap, place it next to it, and then select another cap most like the one just selected and so on. Each tray can be completed in about 2 minutes. The order of FM 100 Hues was input to Famsworth-Mun-sell 100 Hue test scoring software v3.0 to acquire the Total Error Score (TES) and Square Root of Total Error Score (Sqrt TES) and Error Score for each box was separately calculated. The test is performed preoperatively and 1 day, 1 week, and 1 month postoperatively.

Statistical analysis

Descriptive statistical results included the mean, standard deviation, and minimum and maximum values. SPSS version 13.0 (SPSS, Chicago, IL) was used for statistical analysis. Comparisons of the preoperative and postoperative Error Scores were performed with paired t test. One-way Analysis of Variance (ANOVA) was used to determine any significant differences among the box. The Pearson correlation coefficient was used to evaluate the correlations between variables. p value less than 0.05 was considered statistically significant.

RESULT

In 31 myopia patients, the analysis showed that the Square Root of Total Error Score (Sqrt TES) of the FM 100 test was 7.89 ± 2.34. The correlations between Sqrt TES and vision acuity, intraocular pressures, sphere, astigmatism and ages were analyzed. There was positive correlation between Sqrt TES and intraocular pressures (p = 0.045) (Figure 1). Table 1 shows the mean values for parameters and correlation coefficient for the Sqrt TES.

The error scores of the myopias in (blue) box of the FM 100 test were significantly higher than other box (p = 0.000, 0.001, 0.000). Table 2 shows the mean values for Sqrt TES of each box preoperative.

There were not statistical difference between preoperative and 1 day, 1 week, 1 month postoperative for Sqrt TES (p = 0.469, 0.489, 0.146, paired t test). Table 3 shows the mean values for Sqrt TES of preoperative and postoperative.

There were not significant difference for Sqrt TES in box I, II, III, IV at 1 day, 1 week, 1 month postoperative compared with preoperative (p > 0.05, ANOVA test). However, in box IV, there were statistical difference between 1 day and 1 month postoperative (p = 0.018, ANOVA test) (Figure 2). 1 day Sqrt TES was significant higher than the 1 month postoperative values.

The dependency of Sqrt TES in Box IV on time after LASIK surgery is shown in figure 2. 90% patients' visual acuity have up to 20/15, and 10% patients have a visual acuity of 20/10 postoperative.

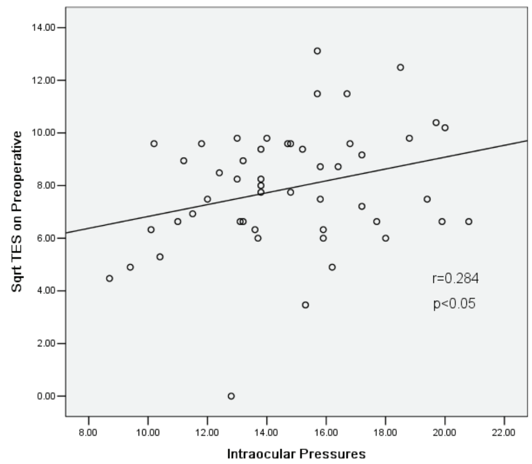

Figure 1: Correlation between Sqrt TES and intraocular pressures preoperative. There was positive correlation between Sqrt TES and intraocular pressures.

Table 1: Preoperative Data and the Correlation with the Sqrt TES.

	Preoperative Sqrt TES		
Parameter	**Mean ± SD**	**r**	***p***
Ages, Y	24 ± 6.56	0.236	0.099
UCVA	0.11 ± 0.08	-0.108	0.456
Sphere, D	-6.18 ± 2.08	0.049	0.738
Astigmatism, D	-0.79 ± 0.88	-0.113	0.434
Intraocular pressures, mmHg	14.73 ± 2.96	0.284	0.045*

*p < 0.05 There was correlation between Sqrt TES and intraocular pressures.

Table 2: Sqrt TES of each Box preoperative.

	Sqrt TES			
	Box I	**Box II**	**Box III**	**Box IV**
Mean ± SD	9.90 ± 8.87	16.88 ± 9.81	26.80 ± 15.16	14.10 ± 12.32
Range	7.38 to 12.42	14.10 to 19.67	22.49 to 31.11	10.60 to 17.60

Table 3: Sqrt TES of color vision in the FM 100 test preoperative and postoperative.

	Sqrt TES			
	Preoperative	**Post-1 day**	**Post-1 week**	**Post-1 month**
Mean ± SD	7.89 ± 2.34	8.08 ± 2.47	7.76 ± 2.16	7.61 ± 2.75
Range	0.00 to 13.12	2.00 to 12.33	2.83 to 12.65	2.00 to 12.65

DISCUSSION

Laser in Situ Keratomileusis (LASIK) has become one of the most popular options for the correction of low to moderate myopia. The most advantage of this procedure is the faster recovery of visual acuity and less pain for recipients. However, this procedure may lead to some complications which are infrequent but have the potential of degrading vision [4]. Most reported LASIK complications are related to the refractive outcome, or to corneal and anterior segment injury and wound healing [5,6]. Generally, the estimating to the outcomes of LASIK postoperative includes UCVA, BSCVA, Aberration and wound healing. But good optical qualities also comprise contrast sensitivity, night vision and color vision [7]. Those complications may be association with the changes of posterior segment of eye body after LASIK [8]. In the process of LASIK, to create a precise lamellar LASIK flap, the Intraocular Pressure (IOP) must be raised to greater than 65 mmHg by a suction ring on the anterior segment of the eye, obviously not a normal physiological state. The actual pressure may be greater than this, because the tonometer used during the procedure is capable only of determining whether IOP is equal to, greater than, or less than 65 mmHg during the surgery. The IOP is returned to normal after the flap is created. The IOP in the surgery could result in temporary ischemia of central retinal artery; vitreoretinal pathologies or changes retinal nerve fiber layer thickness, and longer suction times might be associated with a higher incidence [9,10]. Damage to the retina is possible either through thermal or photochemical processes of excimer laser. Photochemical damage to photoreceptor

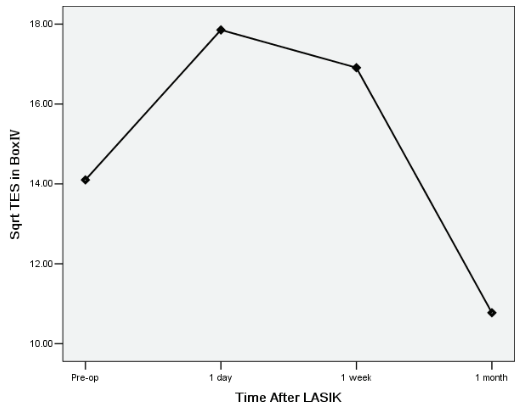

Figure 2: Changes in Sqrt TES in the box IV preoperative and postoperative, 1 day Sqrt TES was significant higher than the 1 month postoperative values. There was not significant difference between preoperative and 1 month postoperative.

cells of the retina can degrade overall light or color sensitivity. The most likely injury when sufficient laser energy is absorbed by the eye is a thermal burn, in which absorption of light by the melanin granules of the epithelium is converted to heat. The focusing of the laser radiation at the cornea and lens within this wavelength band amplifies the irradiance by a factor of approximately 100,000 at the retina [11]. Color vision test is valuable in evaluating retinal and optic nerve diseases after LASIK [12].

Color vision is mediated by three types of photoreceptors-S-, M-, and L-sensitive cones and two chromatic opponent mechanisms [13]. Absence or alteration of any cone type is believed to cause Color Vision Deficiency (CVD) and lead to dichromatic or anomalous trichromatic color vision [14]. In normal eyes, there are many factors that may be associated with color vision. Previous studies had shown the well-known age relation especially of the tritan axis error [15]. Because the patients in our study with a similarly narrow age ranges, so we did not find a correlation with age. Based on our findings, there is significant correlation with intraocular pressures. We found no correlation with sphere, astigmatism, visual acuity preoperative in the FM 100 test. In our research, the error scores of the myopes in (blue) box III of the FM 100 test were significantly higher than other box, in agreement with the findings of Maija Mantyjarvi et al. [16]. The reason for this result was considered that the short wavelength sensitive blue cones (s-cones)(box III) comprise only 10% of the human retinal cones and seem to be more vulnerable in many retinal diseases than the long wave-length red cones (1-cones) or middle wavelength green cones (m-cones).

After LASIK surgery, we detected no significant increase in the Sqrt TES at 1 day, 1 week, and 1 month postoperative. However, we found that in the box IV, there were significant difference between 1 day and 1 month postoperative. Whereas, there not significant difference between preoperative and 1 month. It is assumed that LASIK surgery might result in a great fluctuation in the long wave-length red cones (1-cones) (box IV).

In conclusion, the resolutions to different colors in human eyes are different. The increases of intraocular pressures in LASIK surgery minimal affect the color vision. However, little changes of the fluctuation in the box IV after surgery can be detected in the FM 100 test which is sensitive to color vision deficiency. Studies of larger numbers of patients with longer follow-up are necessaries to further evaluate the changes of color vision after LASIK surgery.

CONFLICTS OF INTEREST AND SOURCE OF FUNDING

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