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Effect of Previous Myopic Laser *In Situ* Keratomileusis on Contrast Sensitivity After Diffractive Multifocal Intraocular Lens Implantations

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Abstract

Objective: To evaluate effects of previous myopic laser *in-situ* keratomileusis (LASIK) on decrease in contrast sensitivity after implantation of diffractive multifocal intraocular lens (MF-IOL).

Methods: Retrospective case series included eyes that were implanted diffractive MF-IOLs after myopic LASIK. Contrast sensitivity was measured 1 month postoperatively and the area under log contrast sensitivity (AULCSF) was calculated. Principle component analysis (PCA) was used for extracting principal factors related with the previous LASIK and MF-IOL implantation. Effects of decrease in postoperative AULCSF and contrast sensitivity at each spatial frequency were evaluated using step-wise multiple regression analysis.

Results: Twenty-six eyes of 20 patients were included. The mean postoperative uncorrected distance visual acuity was -0.06 ± 0.13 logMAR (20/17 in Snellen) and all eyes achieved 20/20 or better. The PCA determined central corneal thickness (CCT), distance-corrected near visual acuity, and absolute manifest refraction as principal factors. The multiple regression analysis revealed that the AULCSF showed significant decrease with a thinner CCT (P=0.017), while a particular trend was not found in the analysis results at the spatial frequencies.

Conclusion: Degradation in contrast sensitivity after implantation of MF-IOLs in post-LASIK eyes was more affected by the amount of the previous LASIK corrections.

Keywords: Laser *in-situ* keratomileusis; Multifocal intraocular lens; Contrast sensitivity; Area under log contrast sensitivity

Introduction

Patients who had undergone laser *in situ* keratomileusis (LASIK) desire implantations of multifocal intraocular lenses (MF-IOLs) for restoring the spectacle independence after cataract surgery. Although outcomes after implantations of MF-IOLs after myopic LASIK were evaluated with limited cases [1,2], the use of MF-IOL has not been recommended [3]. Because, accuracy in lens power calculation is still insufficient after LASIK [4,5], although the MF-IOL necessitates tight tolerance in the residual refractive error [6]. In addition, LASIK degrades contrast sensitivity due to the surgically induced higher-order aberration [7,8]. Implantation of MF-IOL also decreases image contrast on the retina [9], leading to a risk of degradation of contrast sensitivity in high spatial frequencies [10,11]. Whereas, the LASIK treatments after MF-IOL implantation have been performed for refining the residual refraction without significant degradation in the contrast sensitivity [12], since the treatments are considered as safe owing to small amounts of LASIK correction. In our knowledge, the degradation in the contrast sensitivity due to MF-IOL implantation after LASIK has not been investigated. The current retrospective study was to assess the effect of the previous LASIK on the contrast sensitivity after the diffractive MF-IOL implantation.

Patients and Methods

The study was approved by the ethical committee of Tokyo Dental College Suidobashi Hospital, and adhered to the tenets of the Declaration of Helsinki. Written informed consent was obtained before surgery. Clinical records of eyes that had histories of myopic LASIK and consecutively received diffractive MF-IOLs from July 2011 to December 2014 at Tokyo Dental College Suidobashi Hospital, Tokyo, Japan, were reviewed. All patients determined the implantation of the MF-IOL in cataract surgery after risks inherent in implantation of MF-IOL after LASIK were well explained. Eyes that had irregular astigmatism, any history of other ophthalmic surgery, or other ocular and corneal pathology influencing the visual acuity, such as corneal endothelial dysfunction, progressive glaucoma and diabetes mellitus, and retinal detachment, were excluded for the MF-IOL implantation. Eyes that could not reach the postoperative corrected distance visual acuity (CDVA) of 16/20 or better were also excluded from the analysis.

As routine examinations, keratometry, corneal topography, ocular axial length (AL), and central corneal thickness (CCT) were examined preoperatively. The mean keratometric refraction (K) and AL were measured using an auto-keratometer (ARK-700A, Nidek, Gamagori, Japan) and a partial coherence interferometry (IOL Master, Carl Zeiss Meditec AG, Jena, Germany), respectively. The corneal topography and CCT were measured using an anterior-segment optical coherence tomographer (AS-OCT: SS-1000, Tomey, Nagoya, Japan). Powers of the MF-IOLs were determined using a ray-tracing-based power calculation software OKULIX (Tomey) [13]. All eyes were targeted toward emmetropia. Eccentricity (e) on the anterior cornea was also obtained in the OKULIX calculation. One surgeon (HB-M) performed surgeries in the same manner. After removal of cataract by phacoemulsification, diffractive MF-IOLs were implanted in the capsular bag through 2.4 mm corneal incision.

At 1 month postoperatively, uncorrected distance visual acuities (UDVA) and CDVA at 5 m distance, and uncorrected and distance-corrected near visual acuity (UNVA and DCNVA, respectively) at 30 cm were examined. These visual acuities were converted to the logarithm of the minimum angle of resolution (logMAR) notation for analysis. Corneal higher-order aberration (HOA) was measured using a wavefront analyzer (KR-1W, Topcon, Tokyo, Japan) for an area of 4 mm diameter. The root mean square (RMS) of the magnitudes of the third- and fourth-order coefficients of the Zernike expressions was calculated [14]. The contrast sensitivity was examined using CSV-1000 (Vector Vision, Greenville, OH) at 2.5 meters and under illuminations of 85 cd/m^2. Area under the log contrast sensitivity function (AULCSF) was calculated according to the method of Applegate et al. [15].

Analysis

The influence of the additional LASIK treatments on the contrast sensitivity after diffractive MF-IOL implantation was analyzed in two steps.

First, factors that could influence on the postoperative contrast sensitivity were determined by using the principal component analysis (PCA) [16]. LASIK-related factors consisted of the K, AL, CCT, e, and HOA. Myopic LASIK ablations results in decrease in K, increase in e, and decrease in CCT [17,18]. The HOA increases after the LASIK treatment together with decrease in the contrast sensitivity [8,14]. Since majority of the LASIK patients are moderate to high myopia, the ALs are normally longer [19]. The factor related with MF-IOL implantations included the DCNVA, because image contrast on the retina is impaired from multifocality of the MF-IOL [9], and the near visual acuity is sensitive with mild disturbances such as PCO [20]. The absolute value of manifest refraction spherical equivalent (MRSE) postoperatively was also included for compensating the refractive error. In the PCA, eigenvectors with significant eigenvalues were extracted and their projections on the factors were evaluated for identifying principal factors and for avoiding a multicollinearity in the following multiple regression analysis. Number of factors was determined by choosing the significant eigenvalues. For each eigenvalue, products of the coefficients of the eigenvector and the ranges were calculated, and the factor with the maximum product values was selected as the principal factor.

Next, an association between the AULCSF and the factors selected previously was examined using the step-wise multiple regression analysis. It was anticipated that degradations due to the LASIK and MF-IOL implantation would be appeared at the entire [8] and higher spatial frequencies [10,11], respectively. So, the effect on at each spatial frequency was also analyzed.

The results are expressed as the mean ± standard deviation otherwise specified. $P<0.05$ was considered to be statistically significant.

Results

Twenty-six eyes of 20 patients who received diffractive multifocal IOLs after myopic LASIK were included. Mean age of the patients was 48.9 ± 9.6 years (ranging 32 to 63 years), and all patients underwent LASIK at other facilities between 1999 and 2011. The implanted MF-IOLs were ZMA00, ZMB00 (Abbot Medical Optics, Santa Ana, CA, USA), SND1T3, and SND1T5 (Alcon, Ft Worth, TX, USA) IOLs in 2, 22, and 1 eyes, respectively. No intraoperative or postoperative complication was observed in any patients. Demographic data of the subjects before cataract surgery are shown in Table 1. With the sample size and a significant level of 0.05, the detection power in multivariable analysis of two factors was anticipated as 0.95 when R^2 was 0.16.

Number of eyes / patients	26/20
Sex	13 men/7 women
(mean ± standard deviation)	
Age at cataract surgery (years)	48.9 ± 9.6 (range: 32 to 63)
Preoperative corneal refraction (D)	38.49 ± 2.11 (range: 35.5 to 44.4)
Preoperative corneal astigmatism (D)	0.74 ± 0.56 (range: 0.00 to 2.04)
Corneal eccentricity	-0.64 ± 0.19 (range: -0.84 to -0.09)
Ocular axial length (mm)	26.8 ± 1.4 (range: 23.8 to 29.1)
Central corneal thickness (μm)	462.4 ± 33.8 (range: 407 to 523)
Lens power (diopter)	19.9 ± 2.0 (range: 15.5 to 23.0)

Table 1: Demographic data of the subjects before cataract surgery.

The mean postoperative UDVA and CDVA were -0.06 ± 0.13 logMAR (20/17 in Snellen) and -0.15 ± 0.07 logMAR (20/14 in Snellen), respectively, and all eyes achieved CDVA of 20/20 or better. The means of MRSE and the absolute values were -0.03 ± 0.38 D (range: -0.75 to 0.74 D), and 0.27 ± 0.26 D, respectively. The UNVA and DCNVA were 0.09 ± 0.12 logMAR (20/24 in Snellen) and 0.06 ± 0.10 logMAR (20/23 in Snellen), respectively. The corneal HOA within 4 mm diameter was 0.24 ± 0.11 μm rms. The contrast sensitivity was within normal range (Figure 1), while contrast sensitivities at high spatial frequencies were close to the lower boundaries of norm for ages 20 to 59. The AULCSF was calculated as 1.69 ± 0.26, ranging in 1.25-2.26.

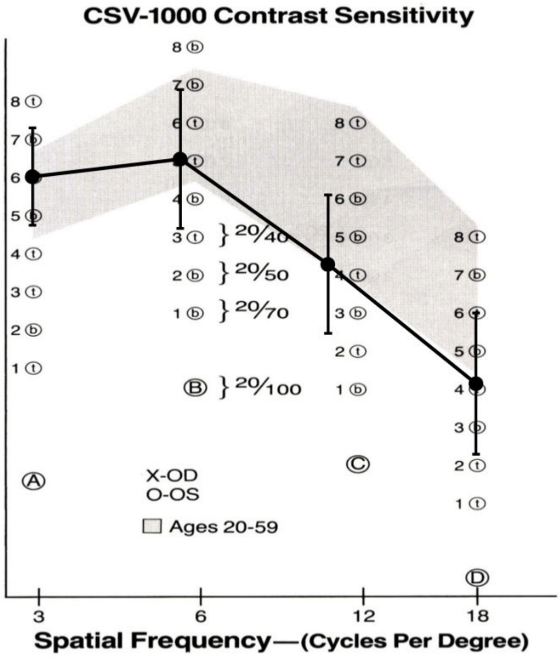

Figure 1. The contrast sensitivity 1 month after implantation of diffractive multifocal IOL in post-LASIK eyes. Mean contrast sensitivities at all spatial frequencies were within the norm of 20-59 ages. cpd=cycles per degree.

The PCA resulted in 3 significant eigenvalues that explained 83% of the variability in the data. The results indicated that there would be 3 or less significant factors, and others should be discarded for avoiding the multicollinearity. The first corresponding to the largest eigenvalue included the AL, CCT, e and K, which were related with the previous LASIK. The second included the DCNVA and HOA that were originated from the ocular optical property after the MF-IOL implantation. The last was the MRSE. With the PCA results, the CCT, DCNVA, and MRSE were selected as the principal factors.

The step-wise multiple regression analysis revealed that the AULCSF significantly decreased with the thinner CCT (P=0.017). The regression equation was AULCSF=0.0034 (95CI: 0.0007–0.0062) × CCT. Table 2 shows the analysis results at the spatial frequencies. The significances of the factors were found at 3, 6, and 18 cpd, however, there was no particular trend observed.

Factor	3 cpd	6 cpd	12 cpd	18 cpd
CCT	0.0011*	0.083	0.051	0.049*
DCNVA	0.028*	0.036*	0.060	0.020*
MRSE	-	-	-	0.66
*denotes statistically significant.				

CCT: Central Corneal Thickness; DCNVA: Distance-Corrected Near Visual Acuity; MRSE: Absolute Values of Manifest Refraction Spherical Equivalent; -: not selected in step-wise analysis.

Table 2: P values obtained with step-wise multiple regression analysis for contrast sensitivity at each spatial frequency.

Discussion

The multiple regression analysis revealed that the CCT was a significant factor influencing the AULCSFs after implantations of diffractive MF-IOLs in post-LASIK eyes, and an influence of the MF-IOL implantation was not found. The analysis at each spatial frequency showed no trend of either the LASIK- or MF-IOL-related contributions. Thinner CCT was resulted from the amount of LASIK correction, and a LASIK of higher correction could increase the HOA and decrease the AULCSF [8]. Therefore, it was demonstrated that degradation in the contrast sensitivity was majorly affected with the previous myopic LASIK.

After MF-IOL implantation of post-LASIK eyes, the postoperative contrast sensitivity could be lost by two different factors. They are related with the previous LASIK and implantation of MF-IOL, and their mechanisms and properties are different each other. The LASIK increases the HOA [8,14] and disturbs the modulation transfer function (MTF) [21], so that degradations of the contrast sensitivity are observed in all spatial frequency [8]. On contrast, implantations of diffractive MF-IOL leads to degradation of image contrasts on the retina due to blurred image by the near focus [9,22], and the contrast sensitivity at higher spatial frequencies decreases [10,11]. The current study did not show a contribution depend on the spatial frequency. We supposed that the sample size was not enough for analyzing the contributions in the spatial frequency.

The current study demonstrated the effect of the previous LASIK, although there is no significant loss of the contrast sensitivity in LASIK refractive error correction after MF-IOL implantation [12]. The contrast sensitivity is more degraded with the amount of LASIK correction due to increases of higher-order aberration and changes in corneal eccentricity [8,14]. Longer AL is also considered as a risk of contrast sensitivity degradation [23]. Linear regression analysis for the current data showed that the K and AL did not correlated with the AULCSF (P=0.057 and 0.066, respectively). As described, the AL or K was not used in the multiple regression analysis for preventing an issue of the multicollinearity. Although the amounts of correction were not available in the current study, it would be supposed that the previous LASIK were undergone for correcting moderate to high myopia. Relation between the amount of LASIK correction and loss of AULSCF should be investigated.

There were limitations in the current study. First, the number of subjects was limited in this retrospective case-series. The use of multifocal IOLs after myopic LASIK was determined only if the patient understood the risk before surgery. Although the resultant R^2 values at 3 and 12 cpd corresponded to the detection power of 0.8 or more, a larger sample size would be preferred for further analysis. Second, all subjects had undergone the LASIK at other facilities and information on the LASIK treatments was not available. During the period of the LASIK procedures, both conventional and wavefront-guided LASIK were commonly performed. The reduction in CCT and increase in HOA depend on the ablation type [7,24] and the amount of correction [14]. However, the ablation type and actual ablation depth could not be identified. Although prospective design for patients in whom the clinical records are available is preferred, it would not be easy and practical. Increasing of subject while would not be easy, is necessary for verifying the finding in the current study.

In conclusion, degradation of contrast sensitivity after implantation of diffractive MF-IOL in post-LASIK eyes was affected by the previous LASIK. Together with a risk in IOL power calculation, it is crucial to understand the risk for the patient and the patient should be selected prudently in the use of multifocal IOL after LASIK.

Meeting Presentation

Presented at the ESCRS 2015 Annual Meeting, September 5-9, 2015, Barcelona.

References

1. Alfonso JF, Madrid-Costa D, Poo-López A, Montés-Micó R (2008) Visual quality after diffractive intraocular lens implantation in eyes with previous myopic laser in situ keratomileusis. J Cataract Refract Surg 34: 1848-1854.
2. Fernández-Vega L, Madrid-Costa D, Alfonso JF, Montés-Micó R, Poo-López A (2009) Optical and visual performance of diffractive intraocular lens implantation after myopic laser in situ keratomileusis. J Cataract Refract Surg 35: 825-832.
3. Khor WB, Afshari NA (2013) The role of presbyopia-correcting intraocular lenses after laser in situ keratomileusis. Curr Opin Ophthalmol 24: 35-40.
4. McCarthy M, Gavanski GM, Paton KE, Holland SP (2011) Intraocular lens power calculations after myopic laser refractive surgery: a comparison of methods in 173 eyes. Ophthalmology 118: 940-944.
5. Yang R, Yeh A, George MR, Rahman M, Boerman H, et al. (2013) Comparison of intraocular lens power calculation methods after myopic laser refractive surgery without previous refractive surgery data. J Cataract Refract Surg 39: 1327-1335.
6. Agresta B, Knorz MC, Kohnen T, Donatti C, Jackson D (2012) Distance and near visual acuity improvement after implantation of multifocal intraocular lenses in cataract patients with presbyopia: a systematic review. J Refract Surg 28: 426-435.
7. Sugar A, Rapuano CJ, Culbertson WW, Huang D, Varley GA, et al. (2002) Laser in situ keratomileusis for myopia and astigmatism: safety and efficacy: a report by the American Academy of Ophthalmology. Ophthalmology 109: 175-187.
8. Yamane N, Miyata K, Samejima T, Hiraoka T, Kiuchi T, et al. (2004) Ocular higher-order aberrations and contrast sensitivity after conventional laser in situ keratomileusis. Invest Ophthalmol Vis Sci 45: 3986-3990.
9. Artal P, Marcos S, Navarro R, Miranda I (1995) Through focus image quality of eyes implanted with monofocal and multifocal intraocular lenses. Opt Eng 34: 772-779.
10. Montés-Micó R, España E, Bueno I, Charman WN, Menezo JL (2004) Visual performance with multifocal intraocular lenses: mesopic contrast sensitivity under distance and near conditions. Ophthalmology 111: 85-96.
11. Zhao G, Zhang J, Zhou Y, Hu L, Che C, et al. (2010) Visual function after monocular implantation of apodized diffractive multifocal or single-piece monofocal intraocular lens Randomized prospective comparison. J Cataract Refract Surg 36: 282-285.
12. Muftuoglu O, Prasher P, Chu C, Mootha VV, Verity SM, et al. (2009) Laser in situ keratomileusis for residual refractive errors after apodized diffractive multifocal intraocular lens implantation. J Cataract Refract Surg. 35: 1063-1071.
13. Minami K, Kataoka Y, Matsunaga J, Ohtani S, Honbou M, et al. (2012) Ray-tracing intraocular lens power calculation using anterior segment optical coherence tomography measurements. J Cataract Refract Surg 38:1758-1763.
14. Oshika T, Klyce SD, Applegate RA, Howland HC, El Danasoury MA (1999) Comparison of corneal wavefront aberrations after photorefractive keratectomy and laser in situ keratomileusis. Am J Ophthalmol 127: 1-7.
15. Applegate RA, Howland HC, Sharp RP, Cottingham AJ, Yee RW (1998) Corneal aberrations and visual performance after radial keratotomy. J Refract Surg 14: 397-407.
16. McAlinden C, Pesudovs K, Moore JE (2010) The development of an instrument to measure quality of vision: the Quality of Vision (QoV) questionnaire. Invest Ophthalmol Vis Sci 51: 5537-5545.
17. Holladay JT, Janes JA (2002) Topographic changes in corneal asphericity and effective optical zone after laser in situ keratomileusis. J Cataract Refract Surg 28: 942-947.
18. Gatinel D, Malet J, Hoang-Xuan T, Azar DT (2004) Corneal asphericity change after excimer laser hyperopic surgery: theoretical effects on corneal profiles and corresponding Zernike expansions. Invest Ophthalmol Vis Sci 45: 1349-1359.
19. Olsen T, Arnarsson A, Sasaki H, Sasaki K, Jonasson F (2007) On the ocular refractive components: the Reykjavik Eye Study. Acta Ophthalmol Scand 85: 361-366.
20. Yoshino M, Bissen-Miyajima H, Oki S, Minami K, Nakamura K (2011) Two-year follow-up after implantation of diffractive aspheric silicone multifocal intraocular lenses. Acta Ophthalmol 89: 617-621.
21. Pérez-Vives C, Dominguez-Vicent A, García-Lázaro S, Ferrer-Blasco T, Montés-Micó R (2012) Optical and visual quality comparison of implantable Collamer lens and laser in situ keratomileusis for myopia using an adaptive optics visual simulator. Eur J Ophthalmol.
22. de Vries NE, Franssen L, Webers CA, Tahzib NG, Cheng YY et al. (2008) Intraocular straylight after implantation of the multifocal AcrySof ReSTOR SA60D3 diffractive intraocular lens. J Cataract Refract Surg 34: 957-962.
23. Yamaguchi T, Negishi K, Kato N, Arai H, Toda I, et al. (2009) Factors affecting contrast sensitivity with the Artisan phakic intraocular lens for high myopia. J Refract Surg 25: 25-32.
24. D'Arcy F, Kirwan C, Qasem Q, O'Keefe M (2012) Prospective contralateral eye study to compare conventional and wavefront-guided laser in situ keratomileusis. Acta Ophthalmol 90: 76-80.