

The Difference Between Higher-Order Aberrations in Myopic Patients Before and After Laser-Assisted in Situ Keratomileusis

B Kozomara*, Milos Milicevic and Dajana Abdulaj

Special Eye Hospital "Svjetlost" Banja Luka, Bosnia-Herzegovina

***Corresponding Author:** B Kozomara, Special Eye Hospital "Svjetlost" Banja Luka, Bosnia-Herzegovina.

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Abstract

Purpose: To compare the level of higher-order aberrations (HOA) before and after laser-assisted in situ keratomileusis (LASIK) in myopic patients.

Methods: Uncorrected (UCDA) and best spectacle-corrected (BSCVA) distance visual acuity, intraocular pressure, and slit-lamp examination of anterior and posterior segments were done to all patients. Corneal topography, pachymetry, keratometry, and HOA was assessed with Oculus Pentacam II.

Moria M2 microkeratome was used to create the corneal flap, while the laser ablation was done with Allegretto 400 Hz laser. All surgeries were binocular and were done by the same surgeon. Four evaluation groups were formed according to the preoperative refractive error. Follow up was one week, 1, 3, 6, and 12 months postoperatively.

Results: A total of 263 patients (526 eyes) were enrolled in this study. A significant increase is noticed after the LASIK procedure in all cases, including the expected changes in pachymetry and keratometry values.

Conclusion: An increase of 64% in a third-order coma and fourth-order spherical aberration is seen postoperatively compared to preoperative values. The level of increase indirectly correlated with the ablation depth.

Keywords: Higher-Order Aberrations; Myopia; LASIK

Introduction

LASIK has been the mainstream of laser vision correction for more than 20 years. Many patients are highly satisfied with the outcomes of the surgery, particularly those with high myopia and myopic astigmatism [1].

However, this procedure raised the question about the influence of higher-order aberrations (HOA) on the visual quality in patients that are not satisfied with the outcomes. The main aberrations that affect vision are third-order (vertical and horizontal coma, and trefoil) and fourth-order HOA (spherical aberration). This effect is particularly problematic with patients that had a higher refractive error, or those with irregular astigmatism preoperatively [2-4].

Wavefront-guided protocols were later established and incorporated in many surgical protocols across the world. Besides correcting the refractive error of the eye (lower-order aberrations), they also improve postoperative outcomes and patient satisfaction by correcting the HOA as well [5-7].

Aim of the Study

This study aims to show the difference between HOA before and after LASIK in myopic patients.

Materials and Methods

This study is designed as a prospective, longitudinal, monocentric, and cross-sectional.

Inclusion criteria for the study are:

- The age between 18 and 50.
- Myopia not less than -1.00 D and not greater than -9.00 D.
- Pupil diameter not larger than 6.00 mm.
- Pachymetry value no less than 550 μm .
- No pathological findings on the anterior and posterior eye segments.
- No intraoperative or postoperative complications.

Exclusion criteria:

- Patients who are less than 18 and more than 50 years of age.
- Myopia less than -1.00 D and more than -8.00 D.
- Pupil diameter of more than 6.00 mm.
- Pachymetry of less than 550 μm .
- Pathological findings on the anterior or posterior eye segments.
- Intraoperative or early postoperative complications.

Preoperative examination

All participants of this study underwent a thorough preoperative examination. Uncorrected (UCDVA) and best spectacle-corrected visual acuity (BSCVA) was determined using the Snellen chart. All those that were 45 years or older also had their uncorrected and best spectacle-corrected near visual acuities (UCNVA, BSCNVA) checked using Jaeger chart. Goldmann contact tonometry was used for the intraocular pressure measurement after digital diagnostics, followed by the slit lamp of the anterior and posterior eye segments.

Scheimpflug imaging was used for keratometry and pachymetry (Oculus Pentacam II, Oculus Optikgerate GmbH, Wetzlar, Germany), while corneal higher-order aberrations were measured with iProfiler (Carl Zeiss Meditech, Jena, Germany).

All surgeries were performed by the same surgeon (B.K.). The excimer laser platform used for all procedures was Wavelight Allegretto 400 Hz (Alcon Laboratories, Forth Worth, TX, USA). Moria M2 microkeratome (Moria, SpA, Antony, France) was used to create 90 μm LASIK flaps.

Four groups were created according to the participants' preoperative refractive error: group I (-0.50 to -2.00 D), Group II (-2.25 D to -4.00 D), Group III (-4.25 D to -6.00 D), and Group IV (-6.25 D to -8.00 D).

RMS third and fourth-order spherical aberrations (coma and spherical aberration) were analyzed preoperatively, as well as one month postoperatively.

Statistical analysis

SPSS 19 software was used for data analysis. Mean, and the standard deviation was calculated using continuous variables, while significance was tested with paired two-tailed student t-test. A p-value of less than 0.05 was considered statistically significant.

Consent

Preoperative consent for surgery, as well as the consent for enrollment into the study, was obtained from every participant.

Results

Patient demographics and characteristics A total of 163 patients (163 eyes) are included in this study. The demographics of the participants are shown in table 1.

Demographic data	
No. of participants (eyes)	263 (526)
Male/Female ratio	136/127
Surgical procedure: both eyes/right eye/left eye	384/78/64
Mean spherical equivalent (SE)	-3.51 ± 1.74
Mean keratometry values (preoperatively)	41.13 ± 17.41
Mean pachymetry values (preoperatively)	565.64 ± 12.41
Mean keratometry values (postoperative)	39.16 ± 11.21
Mean pachymetry values (postoperative)	538.31 ± 10.89

Table 1: Demographics of the study participants.

Visual acuity and refraction

The mean preoperative uncorrected and best spectacle-corrected visual acuities (UDVA, BSCVA) were 0.08 ± 12.31 and 0.71 ± 14.41. One month postoperatively, both UDVA and BSCVA improved to 0.81 ± 7.71, and 0.86 ± 9.54.

Keratometry, pachymetry, and mean spherical equivalent

Mean spherical equivalent (SE), mean keratometry and mean pachymetry values are -3.21 ± 1.74, 43.13 ± 17.41, and 563 µm ± 10.41, respectively. Postoperatively, mean keratometry, and mean pachymetry values are 538.31 ± 10.89 and 39.16 ± 11.21, respectively.

Higher-order aberrations

The mean RMS coma value preoperative and postoperative values are 0.26 ± 0.54, and 0.64 ± 0.37. For spherical aberration (SA), the values for preoperative and postoperative RMS are 0.34 ± 0.15, and 0.54 ± 0.23, or an increase of 40.63%, and 62.96% respectively. The distribution of the mean values between groups is listed in table 2. Statistically significant increase is seen between groups, as the preoperative refractive error increases.

	Groups			
	Group I	Group II	Group III	Group IV
Mean ref. error	-1.44 ± 0.41	-2.96 ± 0.53	-4.83 ± 0.63	-6.74 ± 0.97
Pachymetry	548.79 ± 30.76	561.50 ± 26.43	568.33 ± 21.18	589.54 ± 20.12
Keratometry	43.14 ± 14.10	43.39 ± 21.20	43.61 ± 18.71	45.53 ± 19.21
RMS coma (preoperative)	0.31 ± 1.14	0.31 ± 1.16	0.34 ± 0.17	0.38 ± 0.13
RMS SA (preoperative)	0.36 ± 2.28	0.25 ± 0.40	0.34 ± 1.11	0.35 ± 0.13
RMS coma (postoperative)	0.44 ± 1.14	0.47 ± 1.16	0.51 ± 0.17	0.57 ± 0.13
RMS SA (postoperative)	0.39 ± 2.28	0.43 ± 0.40	0.46 ± 1.11	0.49 ± 0.13

Table 2: Distribution of HOA between groups.

Discussion

Laser vision correction is still the most popular surgical procedure in modern ophthalmology, accounting for more than 50 million patients worldwide. Even though there are many studies that show which refractive error is the most represented in the general population, myopia accounts for 22% of all of them, followed by myopic astigmatism (20%), and hyperopia (12%). Mixed astigmatism accounts for 2 - 3% [8,9].

When it comes to the male/female ratio, results from this study correlate with other available data, where female patients (52%) were more represented than male patients (48%) [10].

An increase in corneal RMS HOA after myopic laser ablation is not uncommon. Due to the changes in corneal morphology after laser ablation and keratometry flattening in myopic patients, corneal RMS coma and SA is expected to rise. In our study, both coma and SA have shown a statistically significant rise in their values postoperatively (40.63% for coma and 62.96% for SA). Many past and current studies have tried to use different optimized ablation techniques in order to lower the level of HOA [11-13]. Wavefront-guided ablation have shown less postoperative HOA than topo-guided [14-17]. The significant increase in postoperative coma and SA in our study can be attributed to the topo-guided method that was used in all cases.

Pupil diameter is also another factor that influences HOA. Higher pupil diameters usually increase the level of corneal HOA, while significantly higher diameters can even cause diplopia [15-19]. The results of this study are based on the fixed 6.00 mm pupil diameter.

Conclusion

In conclusion, we can say that LASIK refractive surgery significantly increases third and fourth-order higher-order aberrations. The degree of increases is directly correlated with the level of intraoperative laser ablation. Future studies should focus on different laser platforms and Femto-flaps.

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