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Evaluation of Corneal High Order Aberrations in Post Laser-Assisted in Situ Keratomileusis versus Photorefractive Keratectomy in Myope

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Abstract

Background *Aberrations of the eye are the difference between two surfaces: the ideal and the actual wave front. Higher order aberrations are a relatively small component, comprising about 10% of the eye's total aberrations. High order aberrations increase with age and minor symmetry exists between the right and the left eyes.* ***Aim and objectives*** *To Compare corneal high order aberrations in post laser-assisted in situ keratomileusis with corneal high order aberrations in post Photorefractive keratectomy in myope.* ***Subjects and methods*** *this study was designed as a prospective randomized intervention study that conducted on 40 myopic eyes. The eyes divided into two randomized groups. Group A: 20 myopic eyes corrected with laser-assisted in situ keratomileusis and Group B: 20 myopic eyes corrected with Photorefractive keratectomy. Cases were collected for LASIK and PRK at operative theater in Beni-Suef University Hospital and clear vision laser center in Cairo, from May 2019 till January 2022.* ***Result*** *There was clinically significant difference between pre- and post-operative visual acuity, vertical trefoil and vertical coma of LASIK group and there was clinically significant between pre- and post-operative visual acuity, vertical trefoil and vertical coma of PRK group. But there was no significant difference between LASIK and PRK in visual acuity, spherical aberration, higher order 5 mm and 6 mm, vertical coma and Vertical trefoil.* ***Conclusion*** *There is non-significant increase in higher order aberration and spherical aberration post LASIK and post PRK with lesser amount in PRK* ***.***

Keywords *Corneal High Order Aberrations, Situ Keratomileusis, Photorefractive Keratectomy, Myope*

1. Introduction

The eye, like any other optical system, suffers from a number of specific optical aberrations. The optical quality of the eye is limited by optical aberrations, diffraction and scatter [1]. The appearance of visual complaints such as halos, glare and monocular diplopia after corneal refractive surgery has long been correlated with the induction of optical aberrations. Several mechanisms may explain the increase in the number of higher-order aberrations with conventional excimer laser refractive procedures: a change in corneal shape toward oblateness or prolateness (after myopic and hyperopic ablations respectively), insufficient optical zone size and imperfect centration. These adverse effects are particularly noticeable when the pupil is large [2].

For light to converge to a perfect point, the wave front emerging from the optical system must be a perfect sphere centered on the image point. The distance in micrometers between the actual wave front and the ideal wave front is the wave front aberration, which is the standard method of showing the aberrations of the eye. Therefore, aberrations of the eye are the difference between two surfaces: the ideal and the actual wave front [3].

In normal population the dominant aberrations are the ordinary second-order spherocylindrical focus errors, which are called refractive errors. Higher order aberrations are a relatively small component, comprising about 10% of the eye's total aberrations [3].

High order aberrations increase with age and minor symmetry exists between the right and the left eyes [4].

There are numerous higher-order aberrations, of which only spherical aberration, coma and trefoil are of clinical interest. Spherical aberration is the cause of night myopia and is commonly increased after myopic LASIK and surface ablation. It results in halos around point images. Spherical aberration exacerbates myopia in low light (night myopia). In brighter conditions, the pupil constricts, blocking the more peripheral rays and minimizing the effect of spherical aberration. As the pupil enlarges, more peripheral rays enter the eye and the focus shifts anteriorly, making the patient slightly more myopic in low-light conditions. In general, the increase in overall wave aberration with pupil size has been reported to increase to approximately the second power of the pupil radius. This is because of the fact that most wave aberration is due to 2nd order aberrations, which have a square radius dependency [5].

The effect of spherical aberration increases as the fourth power of the pupil diameter. Doubling pupil diameter increases spherical aberration 16 times [6].

Thus, a small change in pupil size can cause a significant change in refraction. This possibility should be considered in patients who have fluctuating vision despite well-healed corneas following keratorefractive surgery. Coma is common in patients with decentered corneal grafts, keratoconus, and decentered laser ablations. Trefoil produces less degradation in image quality compared with coma of similar RMS Magnitude [7]. The aim of the work was to compare corneal high order aberrations in post laser-assisted in situ keratomileusis with corneal high order aberrations in post Photorefractive keratectomy in myope.

2. Materials and Methods

This study was designed as a prospective randomized intervention study that conducted on 40 myopic eyes. The eyes divided into two randomized groups. Group A: 20 myopic eyes corrected with laser-assisted in situ keratomileusis and Group B: 20 myopic eyes corrected with Photorefractive keratectomy. Cases were collected for LASIK and PRK at operative theater in Beni-Suef University Hospital and clear vision laser center in Cairo, from May 2019 till January 2022.

Inclusion criteria: All patients were myopic undergo refractive surgery with age above 18.

Exclusion criteria: Age group under 18 years old, Ectatic corneal disease, thin corneas, Active ocular infection, Dry eye, Glaucoma (especially if a large bleb was present), Blepharophimosis, Large pupil size, Systemic or retinal vascular disorder, Autoimmune disease, Pregnancy, Previous ocular surgeries, and all cases with intraoperative complication

The pre-operative evaluation included: Visual Acuity, Slit lamp bio microscopy, Fundus examination, Ocular motility and orbit, corneal topography with ORBSCAN3 Anterior Segment Analyzer Measures, Cycloplegic refraction and analyzes and displays the presence of higher and lower order aberrations using ZYWAVE3 Wavefront Analyzer.

Operative steps: LASIK (laser-assisted in situ keratomileusis) included Topical anesthesia, exposure of the eyeball using a lid speculum, Flap creation which is a soft corneal suction ring was applied to the eye, holding the eye in place once the eye was immobilized, a flap was created by cutting. This process was achieved with a mechanical microkeratome LSK EVOLUTION 2 using a metal blade**.** The flap was folded back, revealing the stroma, the middle section of the corn, Laser remodeling using TECHNOLAS® TENEO™ 317 Excimer Laser and Repositioning of the flap

PRK (Photorefractive keratectomy) included Topical anesthesia, Exposure of the eyeball using a lid speculum,Epithelium removal,Laser remodeling using TECHNOLAS® TENEO™ 317 Excimer Laser. And Use of mitomycin in an attempt to reduce post-operative haze.

Patients were followed up for 3 months postoperatively then higher and lower order aberrations measured using ZYWAVE3 Wavefront Analyzer.

Ethical considerations verbal informed consent was taken from all subjects participating in this study and Ethics committee worked accordance to guidelines and other applicable regulation.

Statistical analysis

At the end of this study data were statistically described in terms of mean ± standard deviation (± SD), median and correlation and percentages when appropriate. Comparison of numerical variables between the two study groups was done using Independent-Samples Mann-Whitney U Test and Paired-Samples T Test. Correlation between groups using Pearson correlation. All statistical calculations were done using computer programs IBM® SPSS® Statistics 21 (Statistical Package for the Social Science). A P-values less than 0.05 was considered significant.

3. Results and Discussion

40 patients eye were enrolled in our study and divided in to two equal groups LASIK group with 12 females eye and 8 males eye and PRK group with 6 females eye and 14 males eye 20 right eyes and 20 left eyes.As shown in table 1 and Figure 1.

Table 1: Sex distribution in the study

Op	Male	Female
LASIK	8	12
PRK	14	6

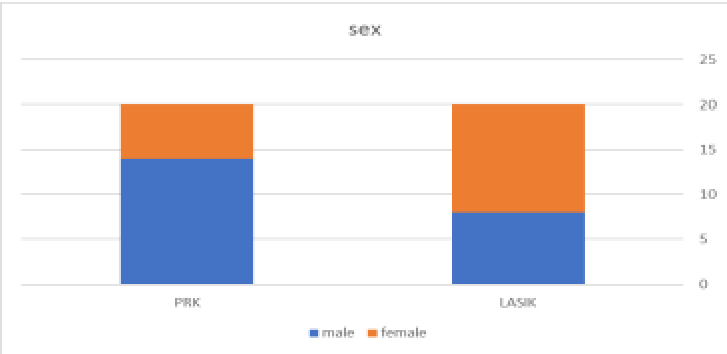

Figure 1: Sex distribution.

Mean age of the LASIK group (±SD) was 25.5 (±4.21),with minimum age 20 and maximum age 32. Mean age of the PRK group (±SD) was 26.5 (±3.73),with minimum age 21 and maximum age 32.which is non signfecant (P value 0.322) in table 2.

Table 2: Age distribution in the study

op	OD	OS
LASIK	10	10
PRK	10	10

There were clinical non-significant changes between preoperative visual acuity of LASIK and PRK (p =0.11), postoperative visual acuity of LASIK and PRK (p =0.264) and mean visual acuity different of LASIK and PRK (p =0.11) while there was clinically significant between pre- and post-operative visual acuity of LASIK group (p =0.0) and pre- and post-operative visual acuity of PRK group (p =0.0) as shown in table 3.

Table 3: Visual acuity

	Op							
	LASIK				PRK			
	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
preVA	0.52	0.22	0.20	0.90	0.48	0.17	0.20	0.80
postVA	0.02	0.04	0.00	0.10	0.00	0.00	0.00	0.00
Diff VA	-0.50	0.2271	-0.2	-0.9	-0.475	0.171	-0.2	-0.8

There were clinical non-significant changes between preoperative Spherical aberration 6mm of LASIK and PRK (p =0.327), postoperative Spherical aberration 6mm of LASIK and PRK (p =0.882), pre- and post-operative Spherical aberration 6mm of LASIK group (p =0.395), pre and post-operative Spherical aberration 5mm of PRK group (p =0.204) and Spherical aberration 5mm Different of LASIK and PRK (p =0.758).

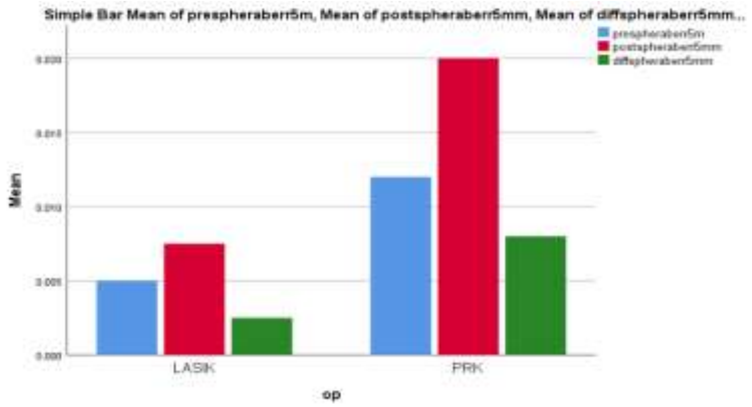

Figure 2: Spherical aberration 5mm.

Table 4: Spherical aberration 6mm

	LASIK				PRK			
	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
prespheraberr6mm	.007	.194	-.790-	.150	.027	.030	.000	.080
postspheraberr6mm	.045	.075	-.160-	.180	.050	.079	.000	.360
diffspheraberr6mm	.038	.193	-.190-	.800	.024	.080	-.070-	.310

There were clinical non-significant changes between preoperative vertical trefoil of LASIK and PRK (p =0.063), postoperative vertical trefoil of LASIK and PRK (p =0.947), pre and post-operative vertical trefoil of LASIK group (p =0.972) and vertical trefoil Different of LASIK and PRK (p =0.142) while there was clinically significant between, and pre and post-operative vertical trefoil of LASIK group (p =0.022) in table 5.

Table 5: Vertical trefoil

	LASIK				PRK			
	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
pre vertical trefoil	-0.050	0.171	-0.410	0.250	-0.157	0.163	-0.440	0.110
post vertical trefoil	-0.048	0.184	-0.400	0.250	-0.045	0.188	-0.370	0.400
diff vertical trefoil	0.00	0.19	-0.66	0.23	-0.11	0.20	-0.44	0.12

There were clinical non-significant changes between preoperative vertical coma of LASIK and PRK (p =0.678), postoperative vertical coma of LASIK and PRK (p =0.165), pre and post-operative vertical coma of LASIK group (p =0.512) and vertical coma Different of LASIK and PRK (p =0.134) while there was clinically significant difference between pre and post-operative vertical coma of PRK group (p =0.005) in table 6.

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Table 6: Vertical coma

	LASIK				PRK			
	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum
pre vertical coma	0.124	0.288	-0.550	0.680	0.179	0.146	-0.010	0.480
post vertical coma	0.095	0.258	-0.430	0.620	0.024	0.118	-0.150	0.210

diff vertical coma	0.03	0.20	-0.35	0.38	0.16	0.22	-0.13	0.59

In our study there were significant visual acuity improvement in both LASIK and PRK with no significant different between them, there was clinically significant increase in higher order aberrations 5mm and 6mm of LASIK group and no significant changes in PRK group with no significant different between them.

The present study demonstrated the correlations between spherical aberration changes and attempted correction in LASIK and PRK procedures for myopia and hyperopia, with regular and WFG ablations.

The occurrence of HOAs following laser vision correction for refractive errors has been reported in many studies. Typically, myopic ablations induce positive spherical aberration (each diopter of myopic correction induces approximately 0.1 ml of spherical aberration) and hyperopic treatments mainly induce negative spherical aberration [8].

The laser–tissue interaction is a complex phenomenon, as the cornea is not like a piece of plastic; it is inherently aspheric and is covered by the epithelium with its remodeling laws. Modern wavefront-optimized ablation profiles pre-compensate for spherical aberration by removing more stromal tissue at the periphery to preserve the prolate shape of the cornea, while WFG treatments are, theoretically, designed to measure and treat both lower-order aberrations and HOAs. A clear reduction in tissue ablation of 10-15% in the corneal periphery was demonstrated by Mrochen and Seiler, even with a 6.5-mm optical zone [9].

There is non-significant increase in LASIK and PRK horizontal trefoil with significant different between them. There is significant improvement in 2nd vertical trefoil PRK with no significant different between PRK and LASIK [10].

In our Study found that both FS-LASIK and Trans PRK caused the anterior corneal surface to become flatter, and the morphology of the corneal surface to become irregular. Corneal higher-order aberrations were significantly increased after the two procedures. Which is not matching our result as changes in method and technic, Trans-PRK using SPT introduced less corneal vertical coma than FS-LASIK which is matching our study [11].

PRK and LASlK may increase ocular higher-order aberrations, but they both have their own features. The difference between the two types of surgery may be correlated with the change of the corneal shape, the conversion of biodynamics "the healing of the corneal cut" and re-structured corneal epithelium and or the stroma [12].

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For the 6mm pupil size, the total HOA increased following both personalized PRK and LASIK with no significant difference between the two groups. Change of the total HOA RMS was influenced by the preoperative values. The known influencing factors could predict nearly 50% of the changes in total HOA [13].

Conclusion:

There is non-significant increase in higher order aberration and spherical aberration post LASIK and post PRK with lesser amount in PRK.

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