https://doi.org/ 10.33472/AFJBS.6.Si3.2024.63-75

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Wavefront Optimized Versus Topography Guided Customized Ablation in Retreatment of Residual Errors of Refraction after LASIK and PRK

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Article History
Volume 6,Issue Si3, 2024
Received:21 Mar 2024
Accepted : 08 May 202
doi: 10.33472/AFJBS.6.Si3.2024.63-75

Abstract

Background: Laser refractive surgery is one of the most common eye surgeries worldwide, and it successfully corrects different refractive errors. **Aim**: the study aimed to compare the refractive outcome of redo by wavefront optimized profile over topography-guided customized ablation profile in residual errors after primary treatment by LASIK or PRK to reach the best visual acuity and least aberration. **Methods**: This was a prospective comparative randomized clinical study (double-armed) carried out from May 2020 to June 2022. Our final cohort included 36 patients (64 eyes) with variable residual errors after LASIK and PRK who were operated on in Al Rowad Eye Hospital (LASIK and refractive surgery department). **Results**: a statistically significant difference between pre- and post-topography guided customized ablation as regards OS spherical and OD spherical refractory findings (p-value <0.0001). While there is no significant difference regarding either OS cylindrical or OD cylindrical, there is a statistically significant difference between pre-and post-wavefront optimized profiles as regards OS spherical and OD spherical refractory findings (p-value 0.004 and 0.005, respectively). While there is no significant difference as regards either OS cylindrical or OD cylindrical. **Conclusion**: Although both topography-guided LASIK and wavefront-optimized LASIK safely and effectively achieved the predicted refractive and visual outcomes, topography-guided LASIK induced fewer HOAs and significantly decreased ocular trefoil, corneal total HOAs, and coma. **Keywords**: **Wavefront Optimized; Topography; Ablation; Errors of Refraction; LASIK**

Introduction

Laser refractive surgery is one of the most common eye surgeries worldwide, and it successfully corrects different refractive errors **(1)**.

Either under-treatment, treatment or regression causes residual errors following laser treatment **(2)**.

Best corrected visual acuity (BCVA) is more excellent following topography-guided customized ablation (TCAT) than wavefront optimized ablation (WFO) **(3)**.

Topography-guided LASIK significantly decreases ocular trefoil, coma and total corneal high-order aberrations **(4)**.

There is a trend to treat residual LASIK errors by flap lift, which shows a more accurate result for refractive outcomes **(5)**.

Twenty-seven per cent of eyes with laser refractive surgery lost one or more lines in best-corrected visual acuity, and patients who underwent retreatment had better visual outcomes **(6)**.

In the current study, we compared the visual outcome after Re-Do for residual errors in patients who underwent LASIK and PRK.

The study aimed to compare the refractive outcome of redo by wavefront optimized profile over topography-guided customized ablation profile in residual errors after primary treatment by LASIK or park.

Patients and Methods

This was a prospective comparative randomized clinical study (double-armed) carried out in the period started from May 2020 to June 2022. Our final cohort included 36 patients (64 eyes) with variable residual errors after LASIK and PRK who were operated on in Al Rowad Eye Hospital (LASIK and refractive surgery department).

The patients were informed about the nature of the procedure, such as retreatment for residual error management and about all the treatment options available. The investigational nature of the study was explained to the patients, and all signed an informed consent form. The study protocol was approved by the local ethical committee of the hospital.

All the patients underwent preoperative evaluation before being registered in the study. The inclusion and exclusion criteria were as follows:

Inclusion criteria: Age 19-45 yrs old**,** stability of refraction with past 1 year, no contact lens user with 2 weeks, spherical equivalent up to (5D) and Met other criteria for redo.

Exclusion criteria: Corneal thickness < 300 μm**,** residual bed < 250μm**,** other coexisting corneal disease**,** increase IOP, Lens opacity, Pregnancy, lactation, Colleagen vascular diseases and K readings not less than 34 in the falttest meridian.

The 36 (64 eyes) patients were randomized into two groups, and each consists of 68 patients: Group (A): Underwent customized ablation 21 patients (39 eyes). Group (B): Underwent wavefront ablation 15 patients (25 eyes)

This was a comparative study, patients were operated by different surgeons.

Evaluation of the patients:

All patients in the study underwent history taking including: Personal history (age, sex, residency, smoking and occupational)**,** Medical history (hypertension, diabetes mellitus, collagen and vascular diseases) and past ocular surgery history.

All patients were subjected to preoperative assessment and detailed ophthalmological examination including: Uncorrected distance visual acuity, Cycloplegic refraction, Corrected distance visual acuity, Manifest refraction, IOP, Slit lamp examination, Scheimpflug based corneal topography (OCULUS Pentacam), Corneal wavefront measurement (OCULUS Pentacam), Postoperative follow up 1,3 and 6 months and Base line preoperative and 6 months postoperative will be analyzied

Success point: Postoperative refraction (- 0.50 D to + 0.50 D) and High order aberrations Rms (u) < 0.15

Procedures

We used Allegretto Wave Eye-Q 500 Hz Excimer Laser System.

Group A: Customized ablation: Topical anesthesia, Lid speculum, Marking of the cornea, Identification of old flap, Application of laser (of pre collected data by I-design) and pentacam, Reposition of the flap, Application of topical antibiotic and steroids and Lid speculum removal

Group B: Customized ablation

Topical anesthesia, Lid speculum, marking of the cornea, Identification of old flap, Application of laser, Reposition of the flap, application of topical antibiotic and steroids and Lid speculum removal

Postoperative: Early post-operative follows up of the patient 1st day after intervention to exclude Haze, stariae, flap, complication and to asses visual acuity. The patients were constructed on topical medication (steroids, antibiotics, and ocular lubricants). Follow up visits were scheduled at one week, 4 weeks, 12 weeks and 24 weeks.

At 1st week patients were assessed to: Refraction, visual acuity and tapering of topical medications

At 4th week patients were assessed to: Stop medications except ocular lubricants, refraction and visual acuity

At 12th week patients were assessed to: I-design for assessment of aberrations, Refraction and visual acuity

At 12th week patients were assessed to: I-design for assessment of aberrations, refraction and visual acuity

Statistical analysis: The data was analyzed by SPSS (statistical package for social science) version 26.0 on IBM compatible computer (SPSS Inc., Chicago, IL, USA). The qualitative data was described as number and percentage "n (%) " and analyzed using the Chi-square and Fisher's exact tests. Quantitative data were tested for normality using the Shapiro-Wilks test, assuming normality at P > 0.05. Quantitative data was described as mean, standard deviation and range, using Student's "t" test, if normally distributed, Mann-Whitney U test, and Kruskal-Wallis test, if not normally distributed. The accepted significance level in this work was started at 0.05 (P < 0.05 was considered significant).

Results

This study was conducted on 36 patients (64 eyes) who underwent LASIK or PRK with residual errors of refraction after primary treatment. 15 patients (25 eyes) underwent wavefront optimized profile while 21 patients (39 eyes) underwent topography guided customized ablation profile. The age of the studied group ranged from 20 to 45 years with mean±SD of 30.78±7.79 years. The studied group included 21 (58.3%) females and 15 (41.7%) males.

Table (1): Socio-demographic data of the studied group (n =36)

		n =36
Age	Mean±SD Range	30.78±7.79 20 – 45
Gender	Male Female	15 (41.7%) 21 (58.3%)
Occupation	House-worker Student Office-based worker Sale	11 (30.6%) 9 (25%) 13 (36.1%) 1 (2.8%)

	Not worker	2 (5.5%)
Past medical history (Hypertension)	Yes No	2 (5.6%) 34 (94.4%)
Smoking	Yes No	9 (25%) 27 (75%)
Type of refractory error	Mixed myopia and astigmatism Mixed hypermetropia and astigmatism Hypermetropia	25 (69.4%) 10 (27.8) 1 (2.8%)
Refractory surgery	LASIK PRK	30 (83.3%) 6 (16.7%)

Table (2) shows that 30.6% among patients are house-workers, 25% among them are students, 36.1% among them are office-based workers, 2.8% are sale and 5.6% are not working. Only 2 patients are hypertensive on medication for 2 years. The past ocular history is free in all patients. 69.4% among patients have both myopia and astigmatism, 27.8% have both hypermetropia and astigmatism and only one patient has only hypermetropia. 83.3% among the patients underwent LASIK while 16.7% among them underwent PRK.

Table (2): Comparison between pre and post primary refractive surgery (either LASIK or PRK) as regard refractory findings (n =36)

			n =36
	Pre-operative	**Post operative**	**P-value**
OD cylindrical (diopter) Mean±SD	1.28±17.64	-0.27±2.38	0.067
OD spherical (diopter) Mean±SD	-1.44±1.41	-1.29±1.06	0.234
OD spherical equivalent Mean±SD	-6.47±34.49	-1.26±1.31	**0.026***
OS cylindrical (diopter) Mean±SD	-22.35±17.24	-0.4±2.39	**0.018***
OS spherical (diopter) Mean±SD	-1.61±1.4	-1.13±0.91	**0.037***
OS spherical equivalent Mean±SD	-11.34±49.55	-1.17±1.21	**0.022***

Table (2) shows a statistically significant difference between pre- and post-operative as regard OD spherical equivalent, OS cylindrical, OS spherical, OS spherical equivalent refractory findings (p-value 0.458, 0.939, 0.773, 0.113, 0.208 and 0.180 respectively). While there is no significant difference as regard either OD cylindrical or OD spherical (p-value 0.067 and 0.234)

Table (3): Comparison between pre and post redo operation (topography guided customized ablation) as regard refractory findings in (n =21)

			n =21
	Pre-operative	**Post operative**	**P-value**
OS cylindrical (diopter) Mean±SD	-0.01±2.01	-0.18±0.22	0.726
OS spherical (diopter) Mean±SD	-0.97±0.75	-0.11±0.15	<**0.0001***
OD cylindrical (diopter)			

Mean±SD	0.18±2.05	-0.16±0.29	0.463
OD spherical (diopter) Mean±SD	-1.33±0.94	-0.07±0.14	**<0.0001***

Table (3) shows a statistically significant difference between pre- and post- topography guided customized ablation as regard OS spherical and OD spherical refractory findings (p-value <0.0001). While there is no significant difference as regard either OS cylindrical or OD cylindrical (p-value 0.726 and 0.463)

Table (4): Comparison between pre and post redo (wavefront optimized profile) as regard refractory findings in (n =15)

			n =15
	Pre-operative	**Post operative**	**P-value**
OS cylindrical (diopter) Mean±SD	-0.92±2.84	-0.04±0.27	0.258
OS spherical (diopter) Mean±SD	-1.35±1.11	-0.23±0.33	**0.004***
OD cylindrical (diopter) Mean±SD	-0.98±2.77	-0.15±0.29	0.312
OD spherical (diopter) Mean±SD	-1.33±1.24	-0.08±0.16	**0.005***

Table (4) shows a statistically significant difference between pre- and post- wavefront optimized profile as regard OS spherical and OD spherical refractory findings (p-value 0.004 and 0.005 respectively). While there is no significant difference as regard either OS cylindrical or OD cylindrical (p-value 0.258 and 0.312)

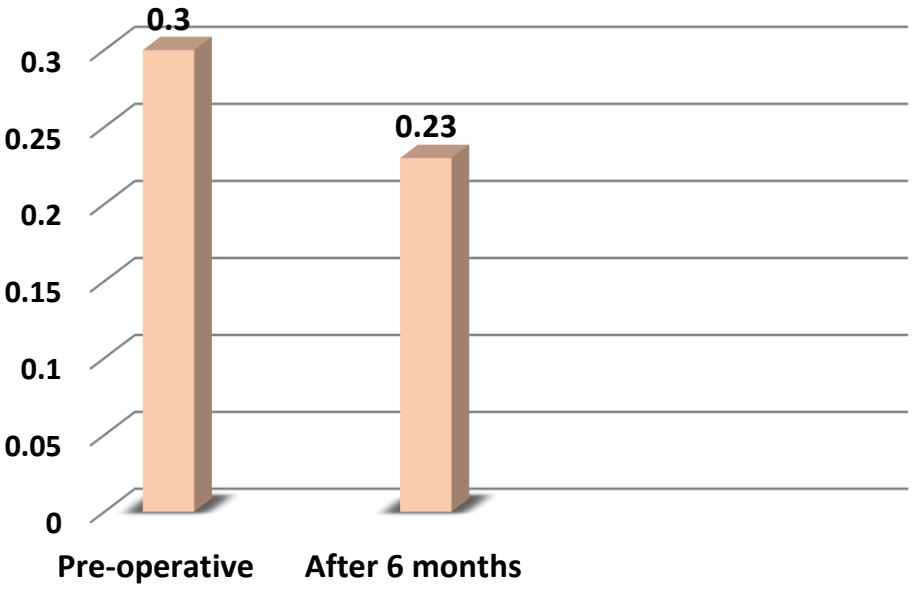

Figure (1): Mean OS HOA aberration pre- and six months after wavefront optimized profile (n =15)

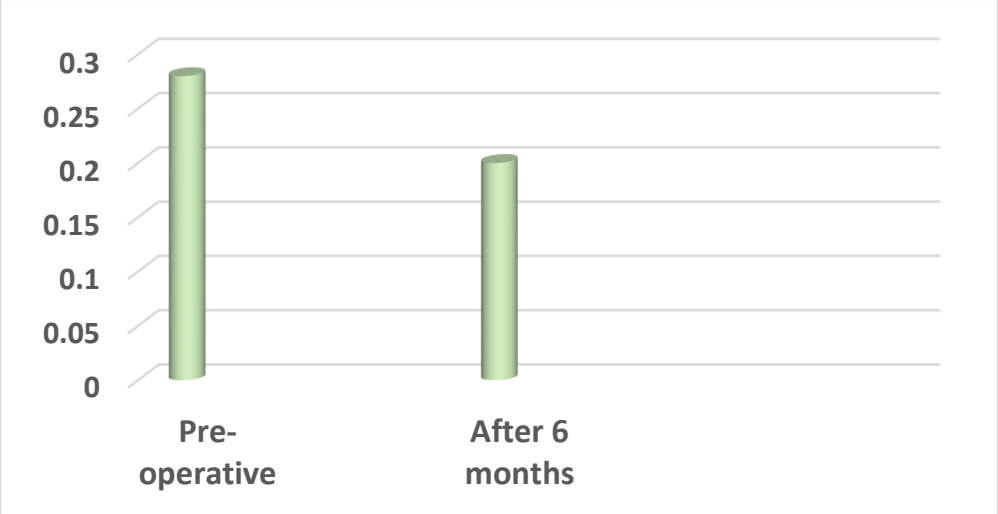

Figure (2): Mean OD HOA aberration pre- and six months after wavefront optimized profile (n =15)

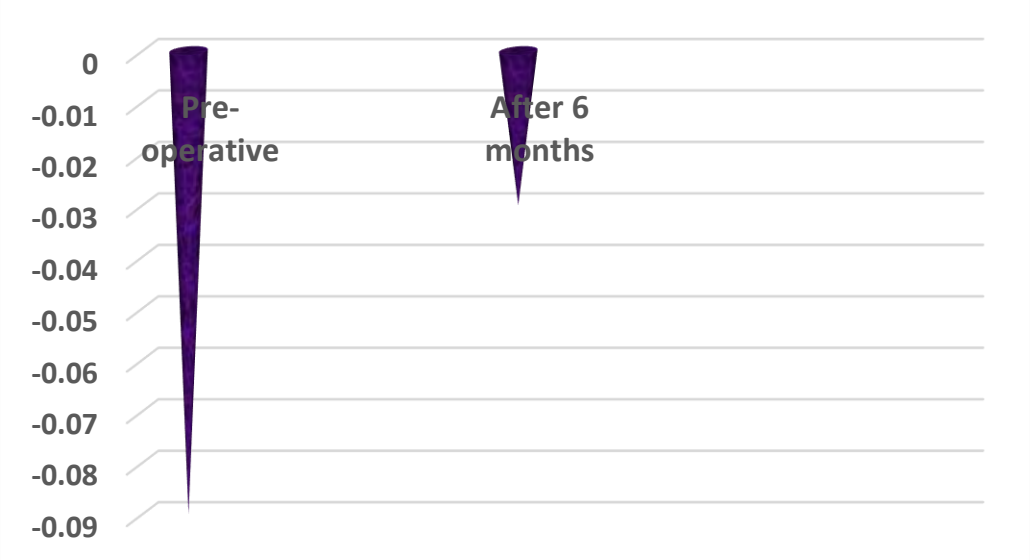

Figure (3): Mean OD coma aberration pre- and six months after wavefront-optimized profile (n =15)

Discussion

This thesis is important because refractive procedures have become the most popular form of ophthalmic surgery nowadays. Despite this, procedures are very accurate but sometimes have residual errors after LASIK and PRK, hence the importance of retreatment for patient satisfaction and visual acuity to get rid of the glasses. Retreatment should be discussed and investigated. Many studies were conducted on this subject.

Our study aimed to compare the refractive outcome of redo by wavefront optimized profile over topography-guided customized ablation profile in residual errors after primary treatment by LASIK or PRK to reach the best visual acuity and least aberration.

In our study, we randomized the patient into two groups: group (A) underwent customized ablation, 21 patients (39 eyes) and group (B) underwent wavefront ablation, 15 patients (25 eyes).

This study compared the results between the two groups by visual acuity, coma, high-order aberration and spherical aberration.

Following our results **(7)** study**,** which was conducted on twenty-six eyes of 20 patients with residual myopia, hyperopia, or mixed astigmatism and/or night vision symptoms after

primary standard LASIK were considered for wavefront-guided customized retreatment using the WaveLight ALLEGRETTO WAVE 200 Hz excimer laser system (model 106). Based on this small series, customized wavefront-guided enhancements using the WaveLight ALLEGRETTO system in patients who underwent previous LASIK appear to be safe and effective in correcting residual refractive error, reducing high-order aberrations, and improving visual symptoms when reliable and reproducible measurements are achieved.
While in disagree with our results, **(8)** study evaluated uncorrected visual acuity (UCVA), best-corrected visual acuity (BCVA), manifest refraction, CS using the Functional Acuity Contrast Test, and HOAs through Zywave aberrometry preoperatively and 6 months after retreatment. Wavefront-guided LASIK using the ZAR algorithm is an effective and safe procedure for treating residual refractive errors. Wavefront-guided LASIK does not increase HOAs and does not modify CS compared with preoperative values. Wavefront-guided LASIK seems to be better than standard LASIK for retreatments.
Also, by our study, **Broderick et al. (1)** reviewed records of patients who underwent WFO PRK retreatments using the Allegretto Wave Eye-Q 400 Hz Excimer Laser System (Alcon Surgical) between January 2008 and April 2011 at Walter Reed Army Medical Center and Madigan Army Medical Center. Outcomes were recorded in terms of uncorrected distance visual acuity (UDVA), manifest refraction spherical equivalent (MRSE), corrected distance visual acuity (CDVA), and complications at 1 month (M), 3 M, and 6 M post-op.
In agreement with our study, **Kim et al. (4)** prospective case study compared the outcomes of topography-guided and wavefront-optimized surgery in patients with laser in situ keratomileusis (LASIK) for myopia. The author found that although both topography-guided LASIK and wavefront-optimized LASIK safely and effectively achieved the predicted refractive and visual outcomes, topography-guided LASIK induced fewer HOAs and significantly decreased ocular trefoil, corneal total HOAs, and coma.

Case Study
Case 1 (Group I: Topography Guided Customized Ablation): 33 years old female patient who has no past medical history of ophthalmological importance.
The power of the original refractive error was: OD: -2.00 / - 1.50 x 70°. OS: -2.25 / - 1.75 x 95°.
The original refractive surgery was LASIK.
After two months, the power of stable residual error was OD: -0.75 / -0.75 x 70°. OS: -0.50 / - 1.00 x 90°.
The time of Re-Do: 4 months later.
Post Re-Do power of refraction: OD: -0.25 / 0 x 0. OS: 0 / 0 x 0.

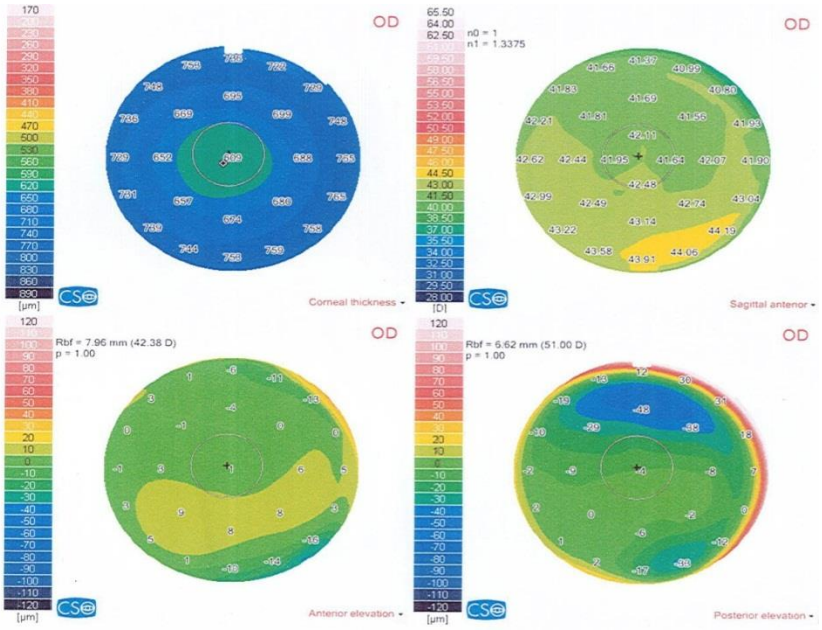

Figure (4): Pentacam pre original surgery (OD).

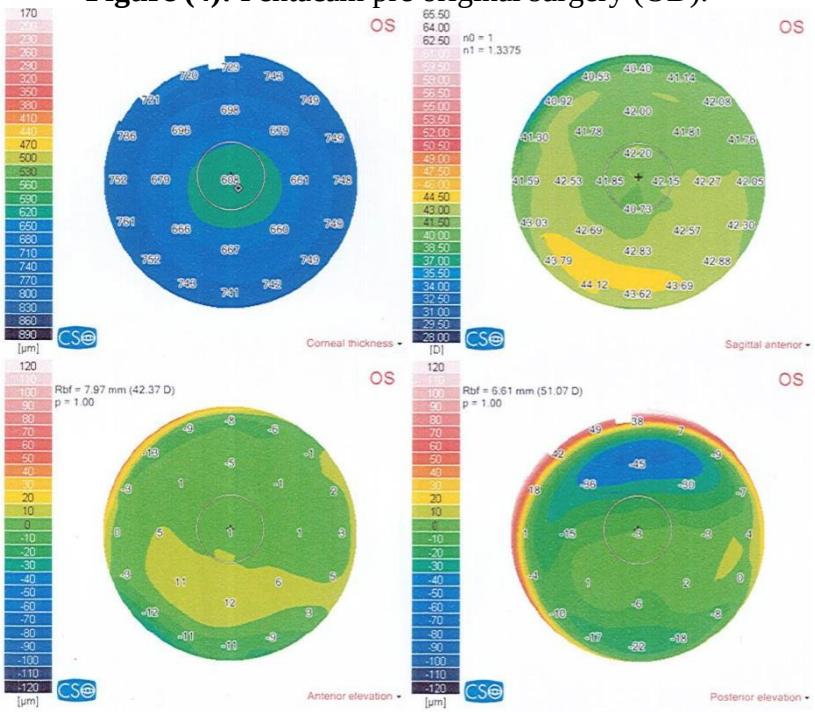

Figure (5): Pentacam pre original surgery (OS).

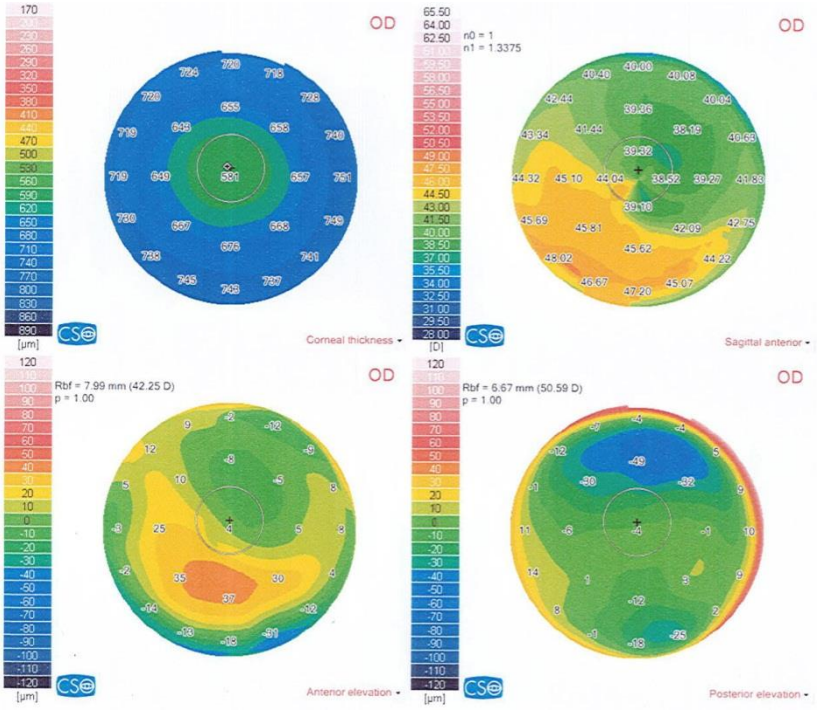

Figure (6): Pentacam pre Re-Do surgery (OD).

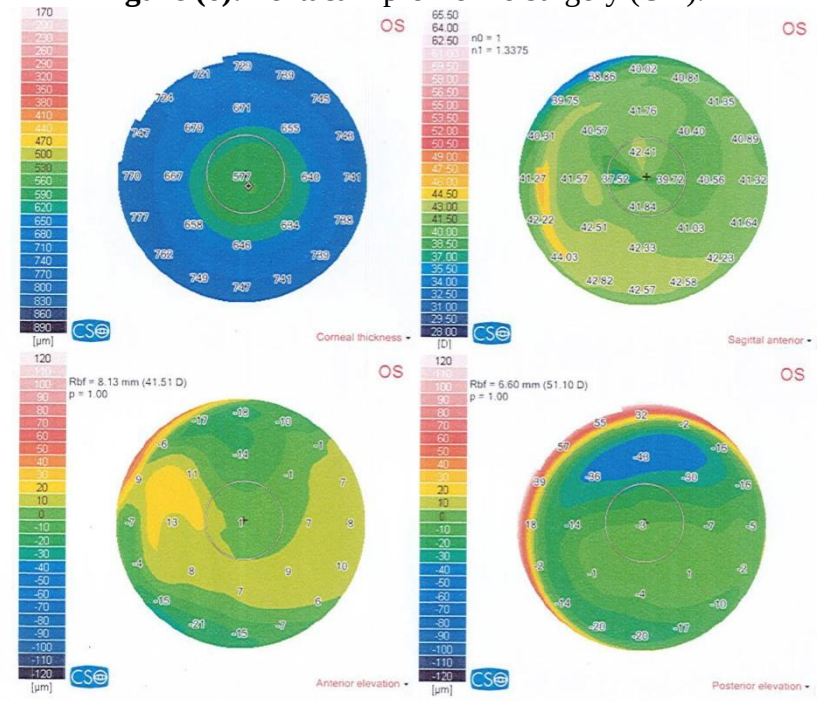

Figure (7): Pentacam pre Re-Do surgery (OS).

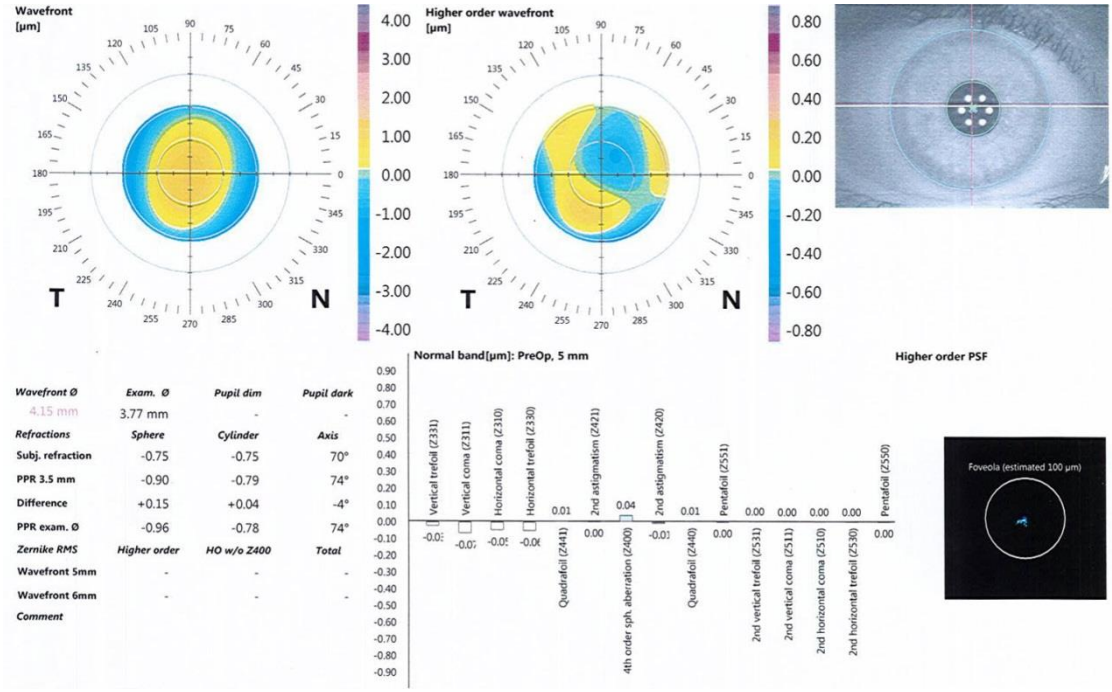

Figure (8): Abberometer post Re-Do (OD).

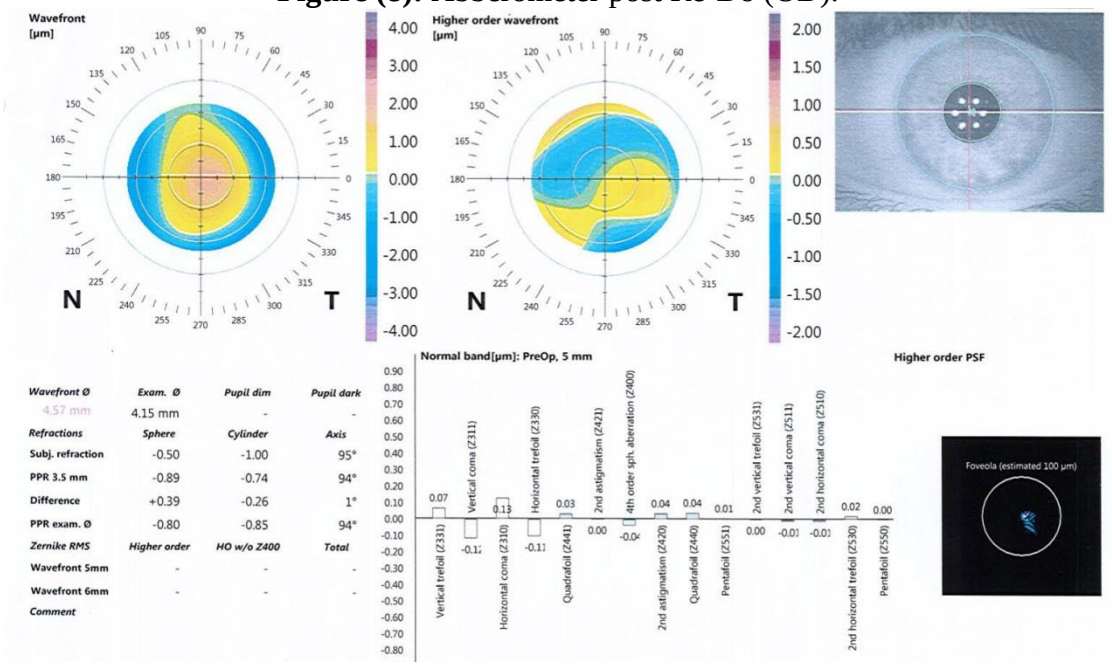

Figure (9): Abberometer post Re-Do (OS).

Case 2 (Group II: Wavefront Optimized Ablation): 29 years old female patient who has not any past medical history of Ophthalmological importance.
The power of original refractive error was: OD: -3.50 / - 2.00 x 90°. OS: -5.00 / - 2.50 x 180°.
Original refractive surgery was LASIK.
The power of stable residual error after two month was: OD: 0 / -1.00 x 90°. OS: -3.75 / -1.25 x 180°.
The time of Re-Do: 8 month later.
Post Re-Do power of refraction: OD: 0 / 0 x 0. OS: 0 / -0.25 x 170°.

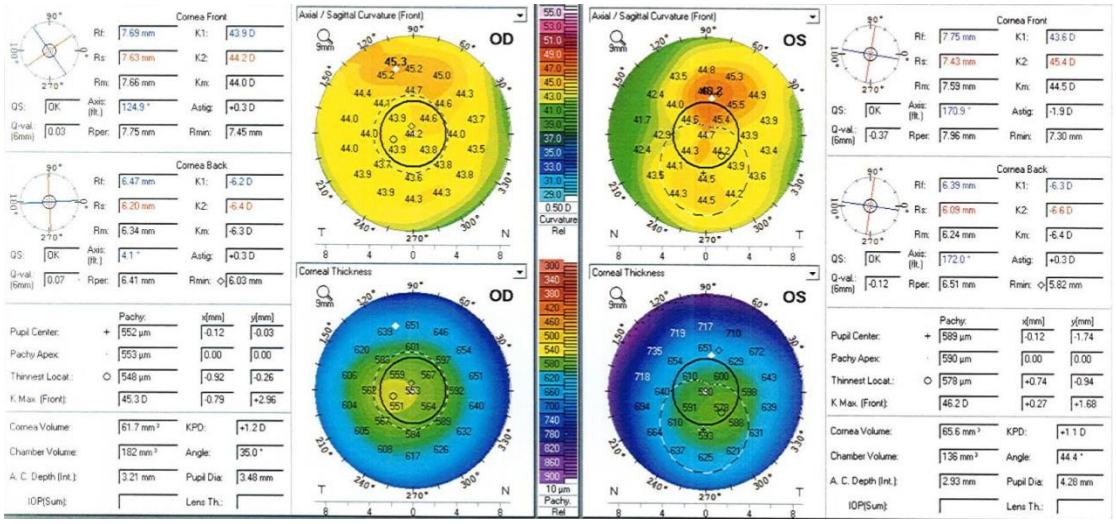

Figure (10): Pentacam showing thickness map pre original surgery (OD/OS).

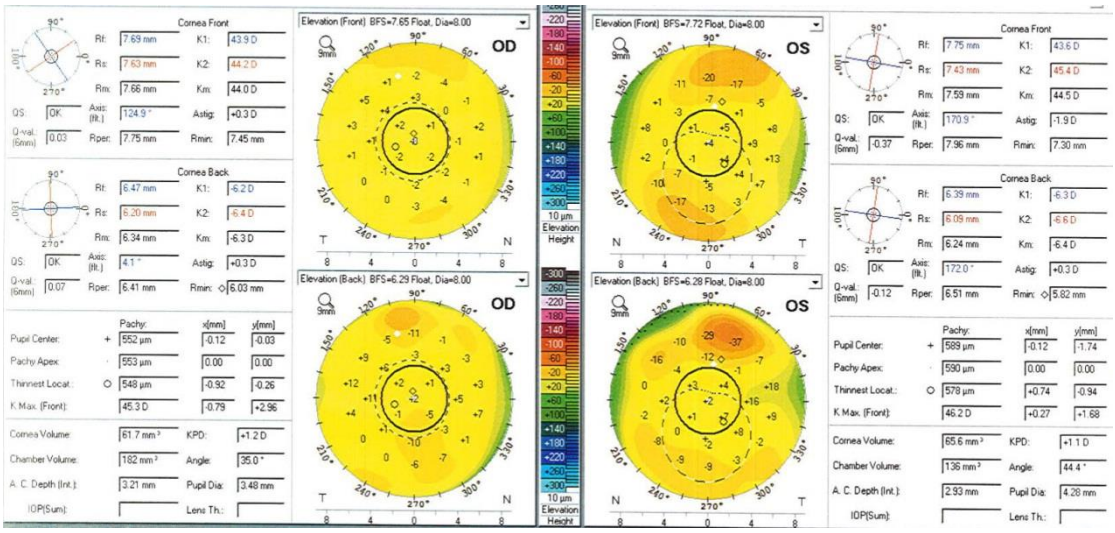

Figure (11): Pentacam showing curvature map pre original surgery (OD/OS).

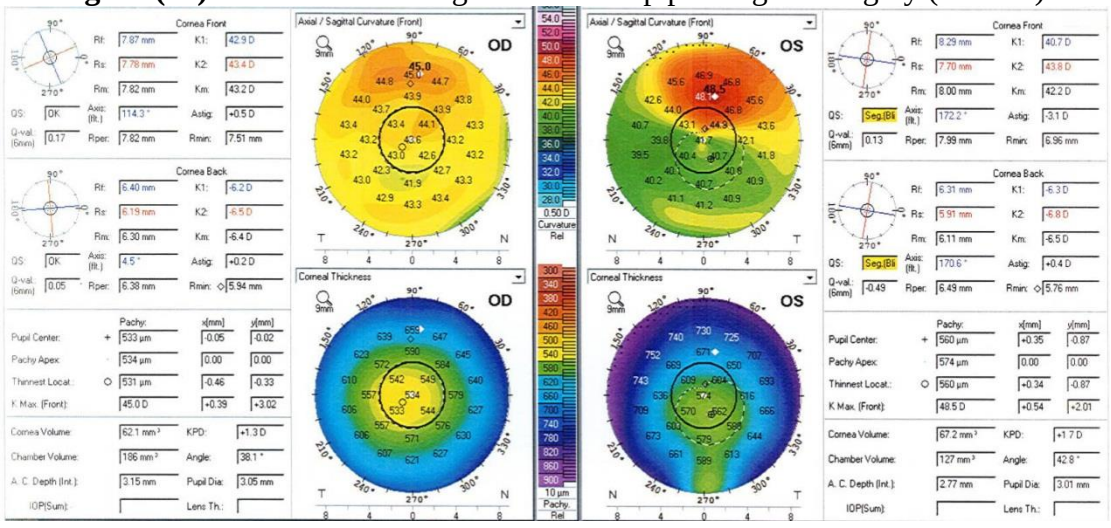

Figure (12): Pentacam showing thickness map pre Re-Do (OD/OS).

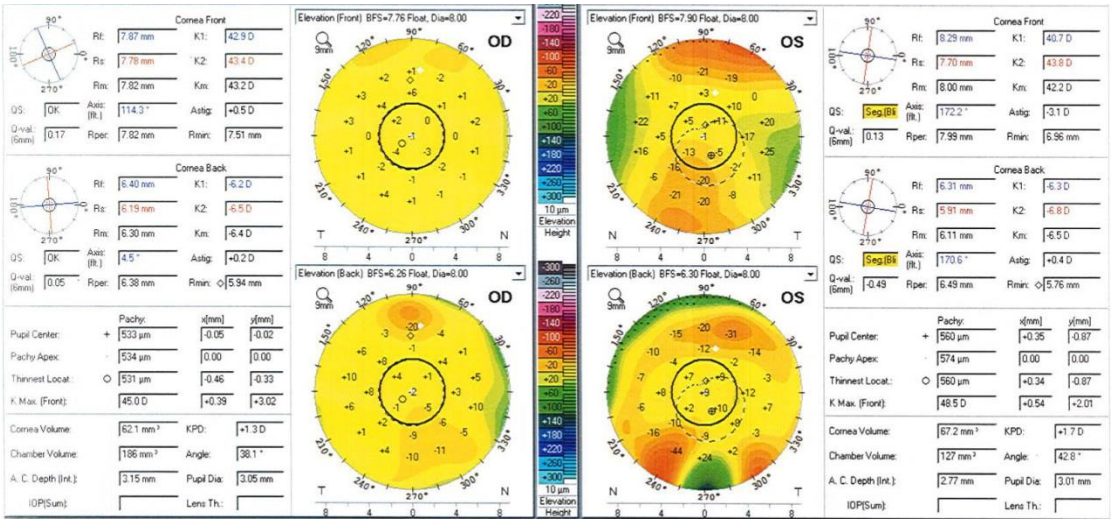

Figure (13): Pentacam showing curvature map pre Re-Do (OD/OS).

Conclusion

This object thesis is important because refractive procedures, such as ophthalmic surgery, have become very popular nowadays. Despite this, procedures are very accurate, but there are sometimes residual errors after LASIK and PRK, hence the importance of retreatment for patient satisfaction and visual acuity to get rid of the glasses. Retreatment should be discussed and investigated. Many studies were conducted on this subject.

Although both topography-guided LASIK and wavefront-optimized LASIK safely and effectively achieved the predicted refractive and visual outcomes, topography-guided LASIK induced fewer HOAs and significantly decreased ocular trefoil, corneal total HOAs, and coma.

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