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ROYAL MAXIM PALACE KEMPINSKI, CAIRO

Functional vision post LVC cataract surgery

By

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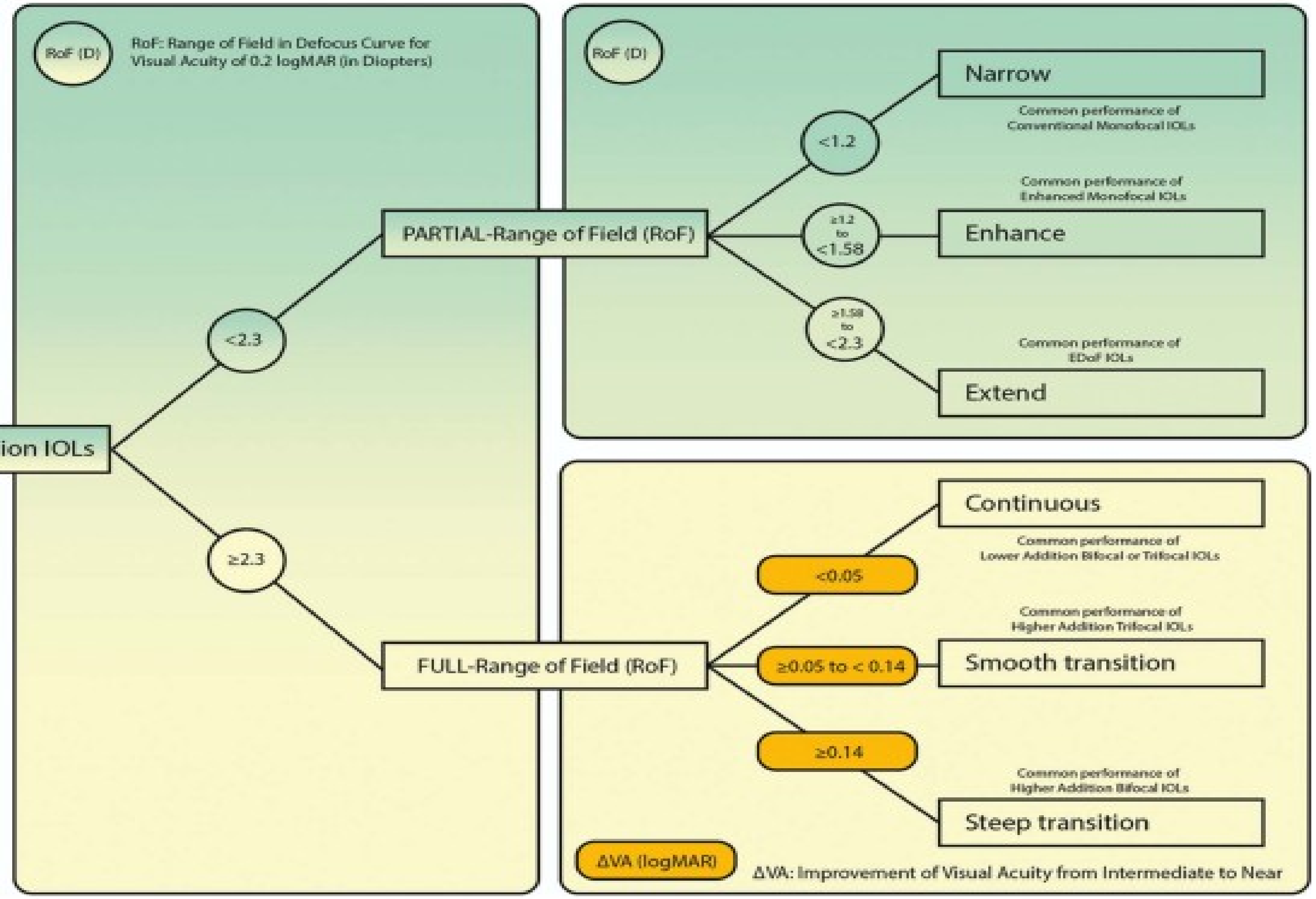
Alexandria University

Egypt

ESCRS Functional Vision Working Group: Evidence-Based Functional Classification of Simultaneous Vision Intraocular Lenses



SPECIAL REPORT

Evidence-based functional classification of simultaneous vision intraocular lenses: seeking a global consensus by the ESCRS Functional Vision Working Group

2024

Filomena Ribeiro, MD, PhD, H. Burkhard Dick, MD, PhD, Thomas Kohnen, MD, PhD, Oliver Findl, MD, PhD, Rudy Nuijts, MD, PhD, Beatrice Cochener, MD, PhD, Joaquín Fernández, MD, PhD

Classifying intraocular lens (IOL) technologies is not an easy task, primarily because of the various categories that can be integrated into a classification. Some of these categories represent different characteristics that may be inappropriately combined in an attempt to create a simplified taxonomy, which is not always feasible. Therefore, when defining an IOL, it is crucial to differentiate between various categories and avoid mixing them, to prevent confusion for the user. These categories include (1) the structure or lens feature (the IOL design), (2) optical outcomes (how light is focused and distributed), and (3) functional outcomes (the patient's visual performance and effect on daily life).

Furthermore, these main categories can be subdivided into subcategories representing different, yet sometimes related, aspects. For example, structure or lens features can be described by the platform, optics, or material. On the other hand, functional outcomes may encompass the range of depth of field (RoF) achieved by the eye and the incidence of negative or positive dysphotopsia (especially glare, starburst, and halo at night). Although there may be a relationship between subcategories from different main categories, such as the optical principle and dysphotopsia, such relationships may vary or be altered depending on how the IOL is classified into other subcategories, such as the number of rings in a diffractive structure, the number of main foci and the distance between foci, or the light distribution between foci. This may lead to discrepancy between the theoretical properties on the optical bench and the clinical outcome even more with the perception reported by the patient.

In summary, IOLs can be classified by multiple categories that convey different information (Table 1). Surgeons should not assume that a classification in an optical category will predict outcomes in a specific functional category, and vice versa, because of complex relationships with other subcategories that can act as confounding factors.

At this point, some important issues can be identified that necessitate the development of an evidence-based functional classification. First, it is imperative for authors to refrain from combining classification categories that encompass distinct attributes of the IOLs. It is common for standards to mix optical and functional concepts. For example, ISO 11979-7:2024 uses the term multifocal or extended depth of focus (EDF), but the characteristics of the foci are not defined. Even functional outcomes such as visual acuity (VA) or RoF are used to classify IOLs in these categories.[1] Using the term "field" instead of "focus," that is, extended depth of field instead of extended depth of focus,[2] in the classification based on the RoF accurately represents what is being measured through defocus curves.[3] From an optical point of view, the corresponding terminology is "through-focus response."[4] Therefore, for classifying an IOL as bifocal, trifocal, extended depth-of-focus, etc., the through-focus response evaluation in the optical bench should be used instead of functional outcomes such as the defocus curve. The through-focus response does not define any standard thresholds, so the classification of IOLs as bifocal, trifocal, EDF, etc. is often based on personal perceptions rather than solid evidence.

OPTICAL TECHNOLOGIES

Two main types of optical technologies, diffractive and refractive, have historically been used to classify IOLs, depending on the optical principles used for focusing light.[5] Diffraction and refraction can be achieved through distinct

LVC induces higher order aberrations.

Causes :

- Discrepancies due to laser efficiency losses on a curved surface.
- Ablation plume shielding effect

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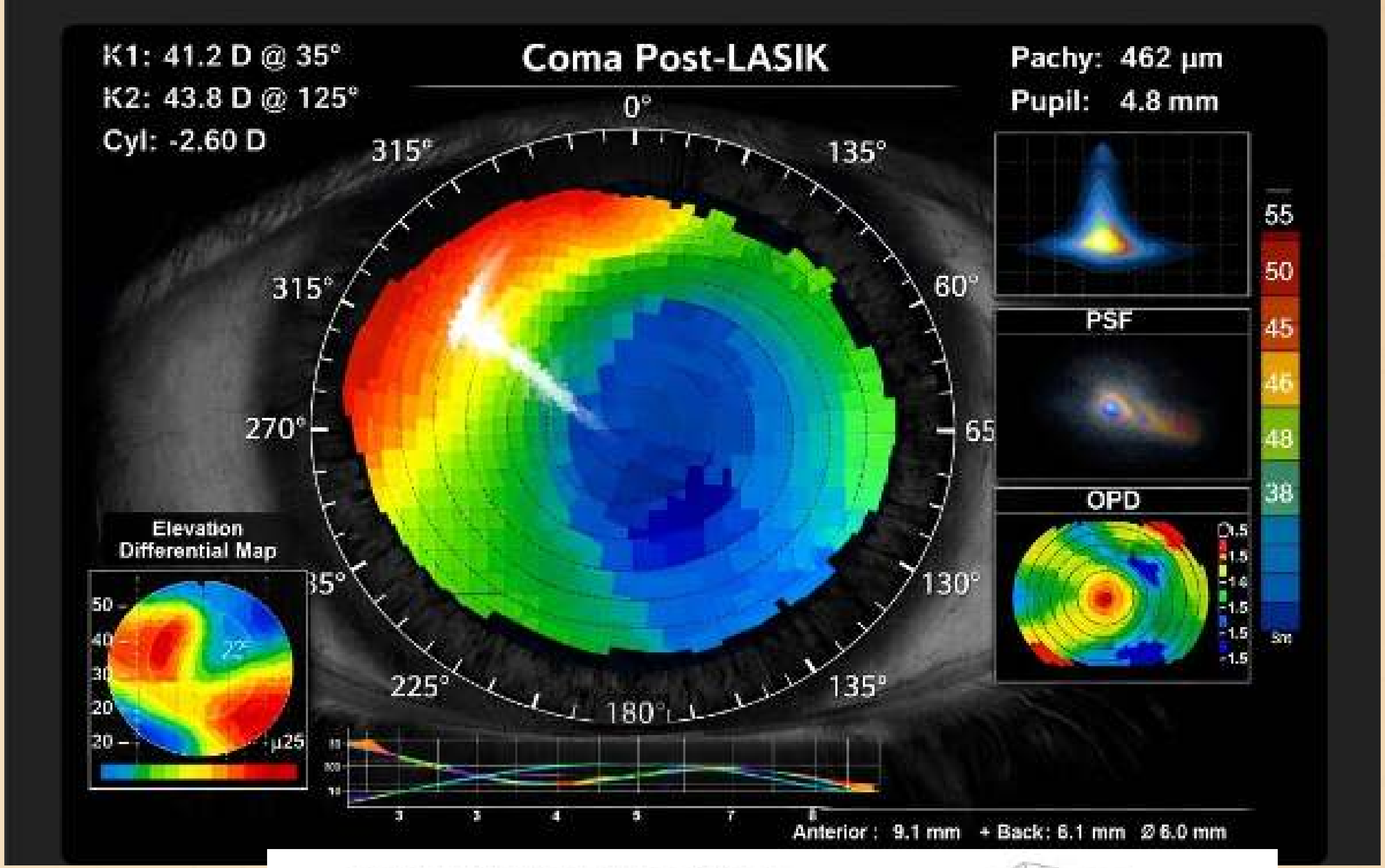
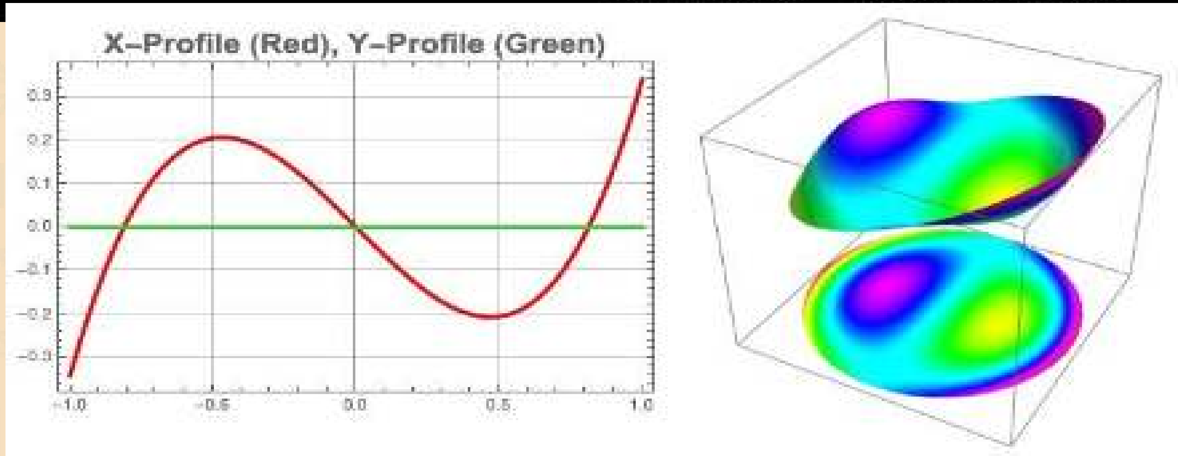
Total and corneal optical aberrations induced by laser in situ keratomileusis.
J Refract Surg 2004:20;203-216


K1: 41.2 D @ 35°
K2: 43.8 D @ 125°
Cyl: -2.60 D
Coma Post-LASIK
Pachy: 462 µm
Pupil: 4.8 mm
0°
315°
135°
315°
60°
270°
65
130°
225°
180°
135°
PSF
OPD
55
50
45
46
48
38
Elevation
Differential Map
Anterior : 9.1 mm
+ Back: 6.1 mm
Ø 6.0 mm


X–Profile (Red), Y–Profile (Green)
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0.2
0.1
0.0
−0.1
−0.2
−0.3
−1.0
−0.5
0.0
0.5
1.0

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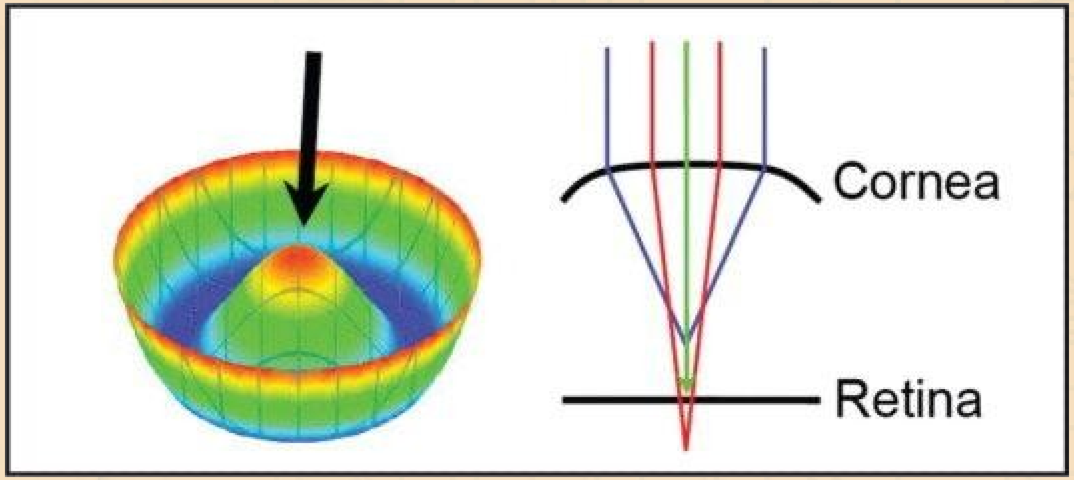
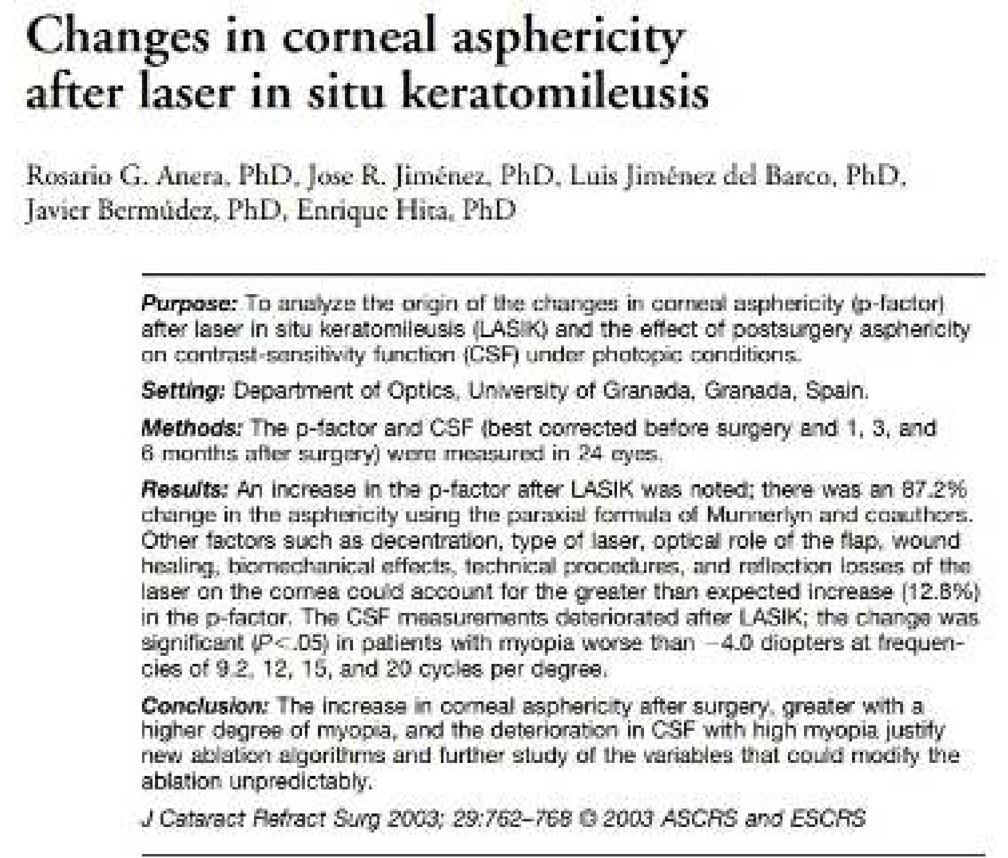
LVC induces Spherical aberrations:

-Myopic LASIK induces positive SA.
-Hyperopic LASIK induces negative SA.

The magnitude of induction of SA is proportional to the magnitude of the spherical correction.





Changes in corneal asphericity after laser in situ keratomileusis

Rosario G. Anera, PhD, Jose R. Jiménez, PhD, Luis Jiménez del Barco, PhD, Javier Bermúdez, PhD, Enrique Hita, PhD

Purpose: To analyze the origin of the changes in corneal asphericity (p-factor) after laser in situ keratomileusis (LASIK) and the effect of postsurgery asphericity on contrast-sensitivity function (CSF) under photopic conditions.

Setting: Department of Optics, University of Granada, Granada, Spain.

Methods: The p-factor and CSF (best corrected before surgery and 1, 3, and 6 months after surgery) were measured in 24 eyes.

Results: An increase in the p-factor after LASIK was noted; there was an 87.2% change in the asphericity using the paraxial formula of Munnerlyn and coauthors. Other factors such as decentration, type of laser, optical role of the flap, wound healing, biomechanical effects, technical procedures, and reflection losses of the laser on the cornea could account for the greater than expected increase (12.8%) in the p-factor. The CSF measurements deteriorated after LASIK; the change was significant ($P<.05$) in patients with myopia worse than −4.0 diopters at frequencies of 9.2, 12, 15, and 20 cycles per degree.

Conclusion: The increase in corneal asphericity after surgery, greater with a higher degree of myopia, and the deterioration in CSF with high myopia justify new ablation algorithms and further study of the variables that could modify the ablation unpredictably.

J Cataract Refract Surg 2003; 29:752–768 © 2003 ASCRS and ESCRS

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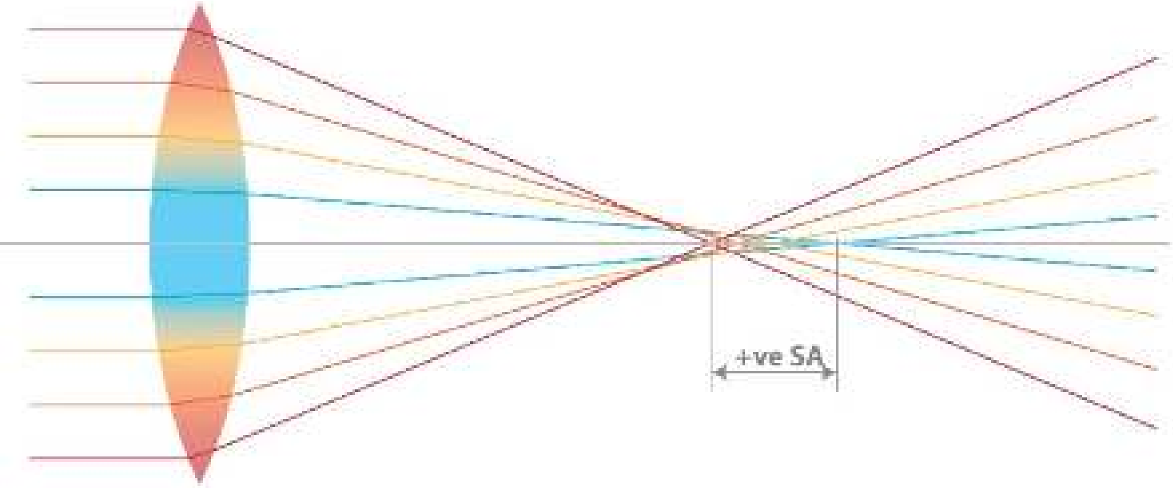
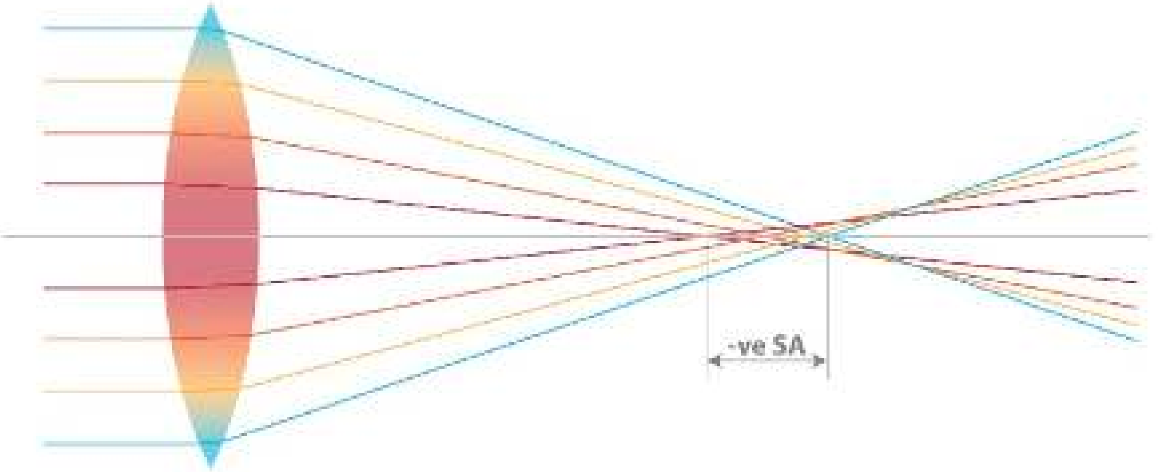
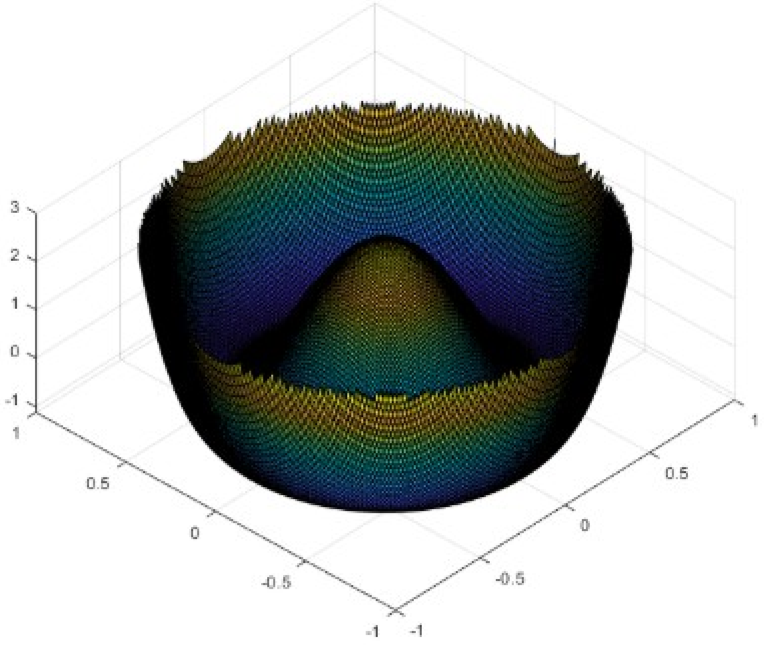


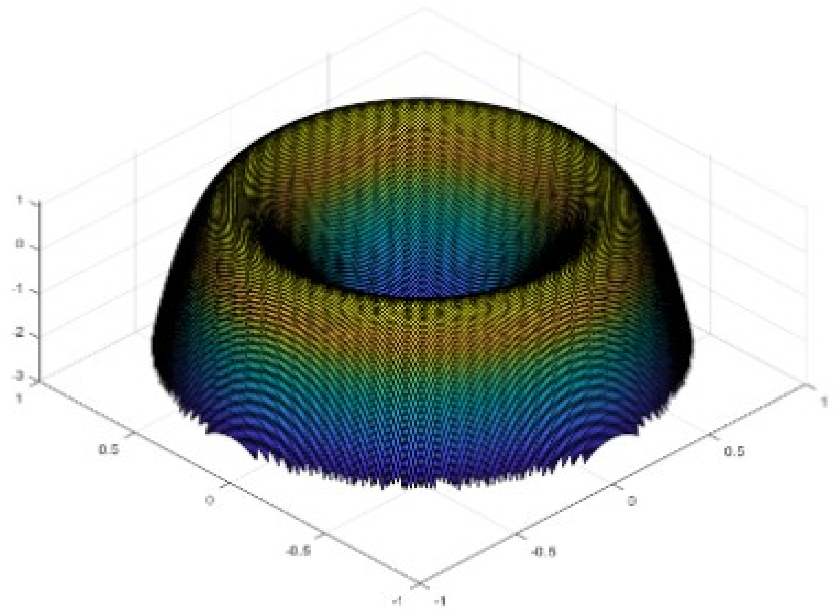
Positive SA: peripheral rays are refracted by a greater amount than central rays.



Negative SA: peripheral rays are refracted by a lesser amount than central rays.

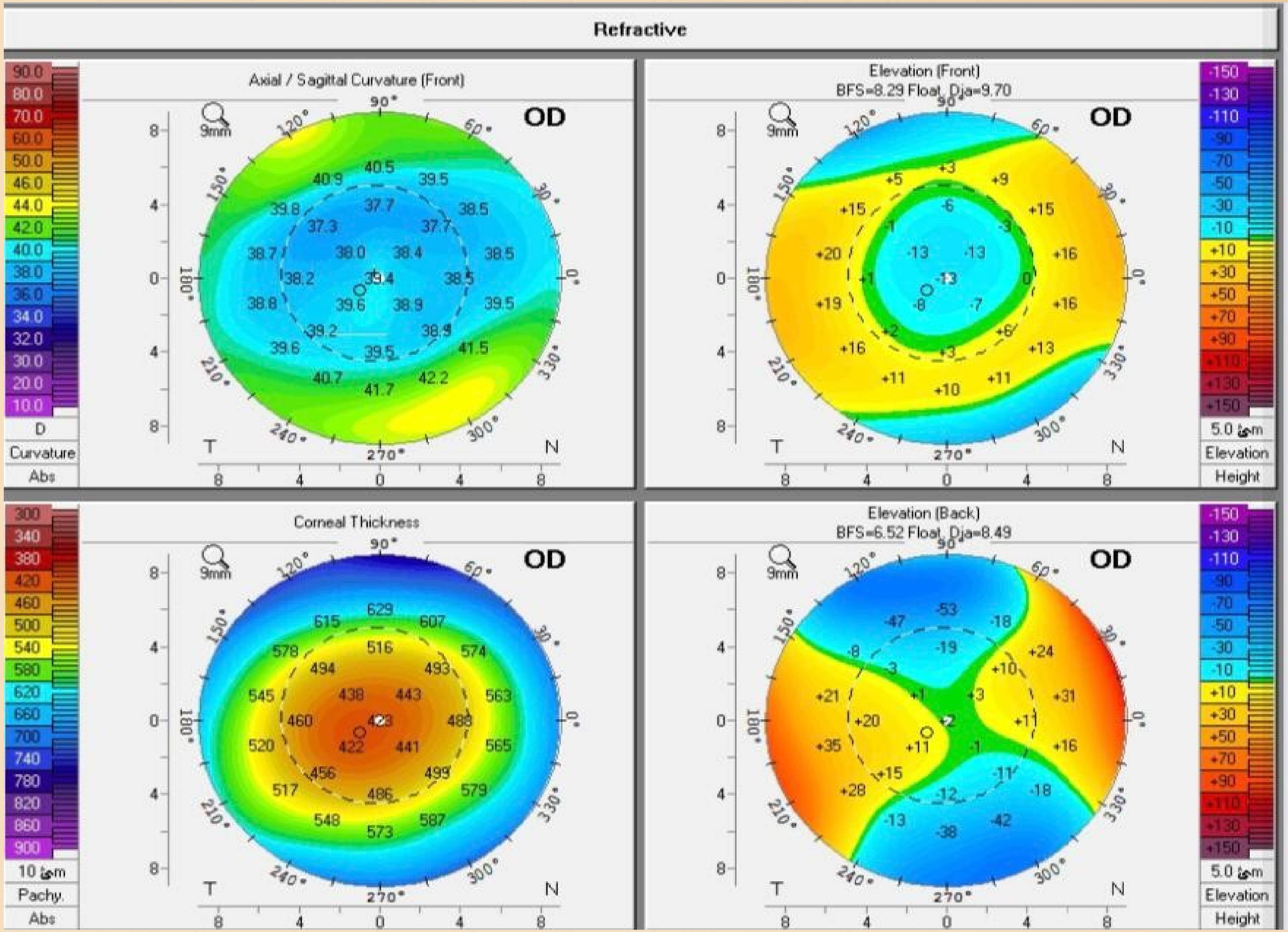


Zernike notation illustration of positive SA, an inverted lipped bowl.



Zernike notation illustration of negative SA, a lipped bowl.

Post myopic Lasik



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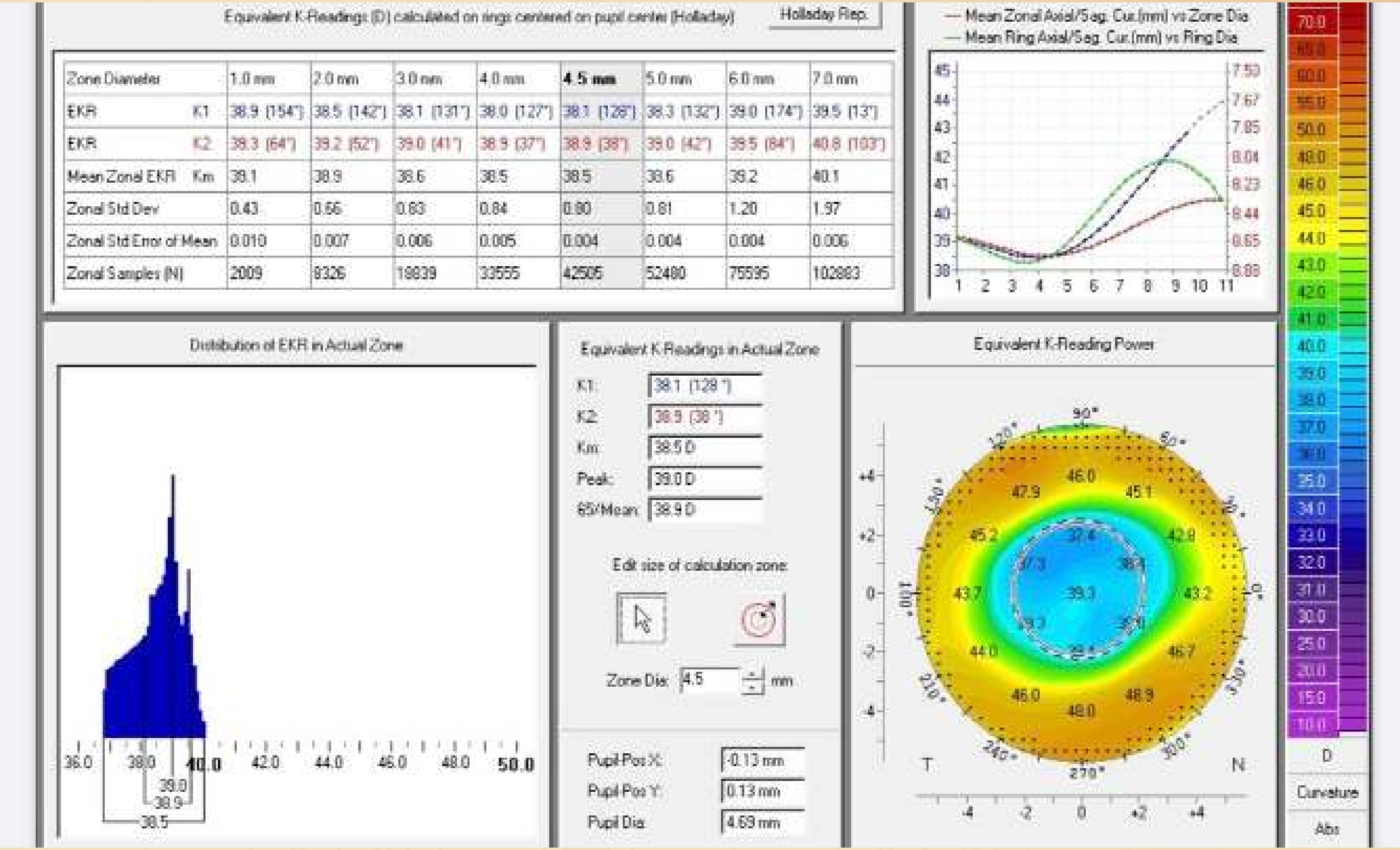

Zone Diameter		1.0 mm	2.0 mm	3.0 mm	4.0 mm	**4.5 mm**	5.0 mm	6.0 mm	7.0 mm
EKR	K1	38.9 (154°)	38.5 (142°)	38.1 (131°)	38.0 (127°)	38.1 (128°)	38.3 (132°)	39.0 (174°)	39.5 (13°)
EKR	K2	38.3 (64°)	39.2 (52°)	39.0 (41°)	38.9 (37°)	38.9 (38°)	39.0 (42°)	39.5 (84°)	40.8 (103°)
Mean Zonal EKR	Km	38.1	38.9	38.6	38.5	38.5	38.6	39.2	40.1
Zonal Std Dev		0.43	0.66	0.83	0.84	0.80	0.81	1.20	1.97
Zonal Std Error of Mean		0.010	0.007	0.006	0.005	0.004	0.004	0.004	0.006
Zonal Samples (N)		2009	8326	18839	33555	42505	52480	75595	102883

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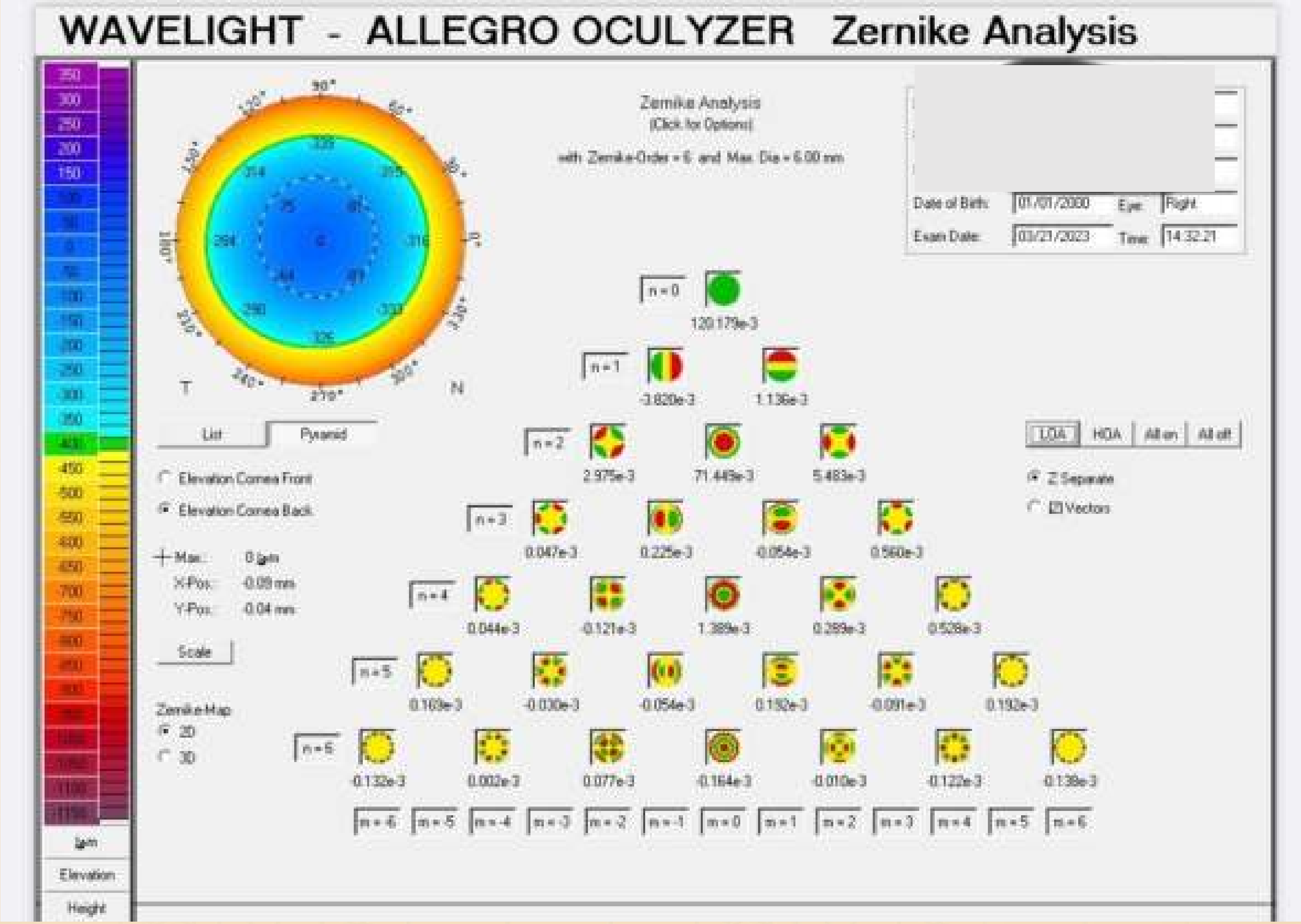
WAVELIGHT - ALLEGRO OCULYZER Zernike Analysis
Zernike Analysis
(Click for Options)
with Zernike-Order = 6 and Max. Dia = 6.00 mm
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Eye: Right
Exam Date: 03/21/2023
Time: 14:32:21
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m = 2
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m = 4
m = 5
m = 6
List
Pyramid
Elevation Cornea Front
Elevation Cornea Back
Max: 0 µm
X-Pos: -0.09 mm
Y-Pos: 0.04 mm
Scale
Zernike-Map
2D
3D
LOA
HOA
All on
All off
Z Separate
Vectors
T
N
90°
270°
µm
Elevation
Height

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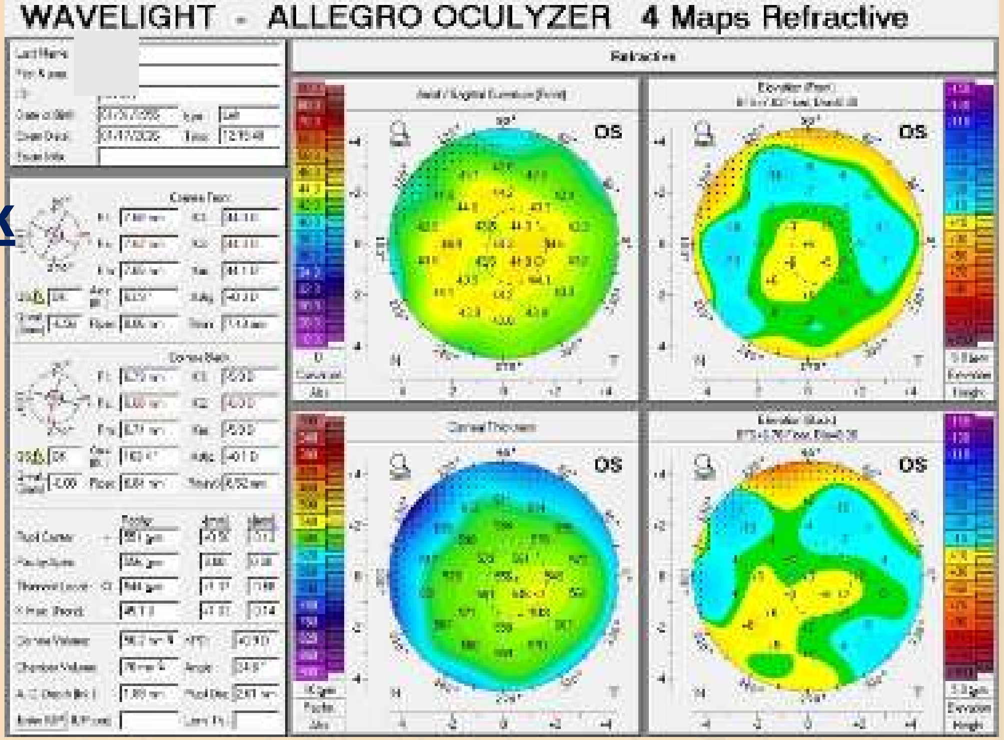
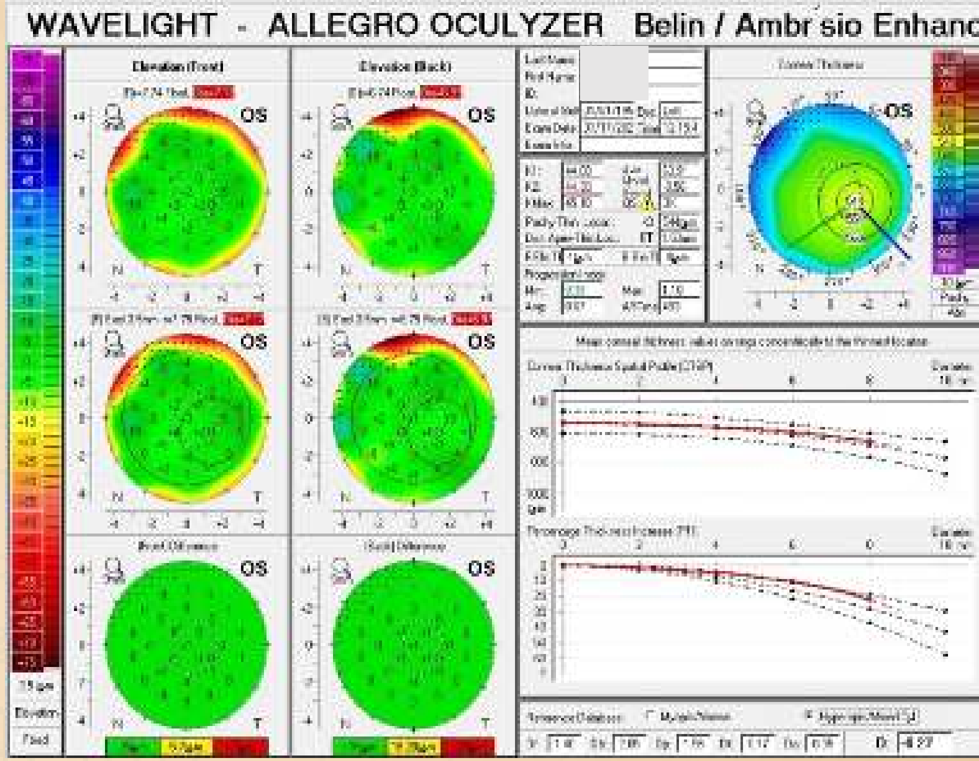
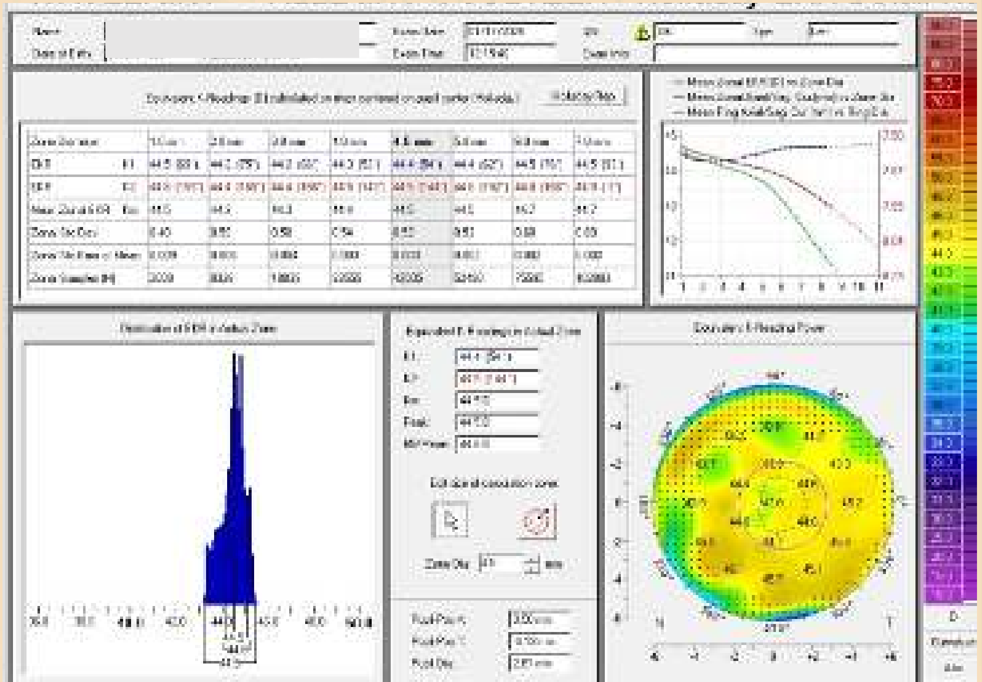
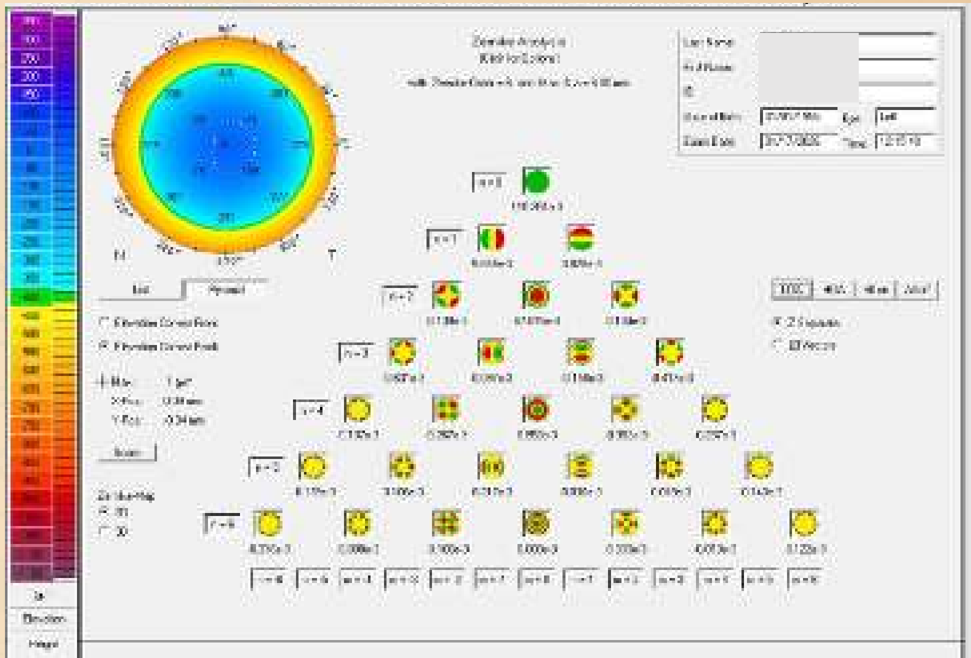
Post Hyperopic lasik









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LVC induces Coma

Studies have shown that the size of halos increases more symmetrically with +ve SA and –ve SA degrading the visual quality

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Pupil size effect

The larger the pupil the more the degradation of the optical quality in post-LASIK eyes. Study compared the effect of 2 pupillary sizes and concluded that a larger halos in post-LASIK eyes for 5 mm than 3 mm pupils

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❖ Choosing the proper Presbyopia-correcting IOL In patients with reshaped corneas is still

Very Challenging

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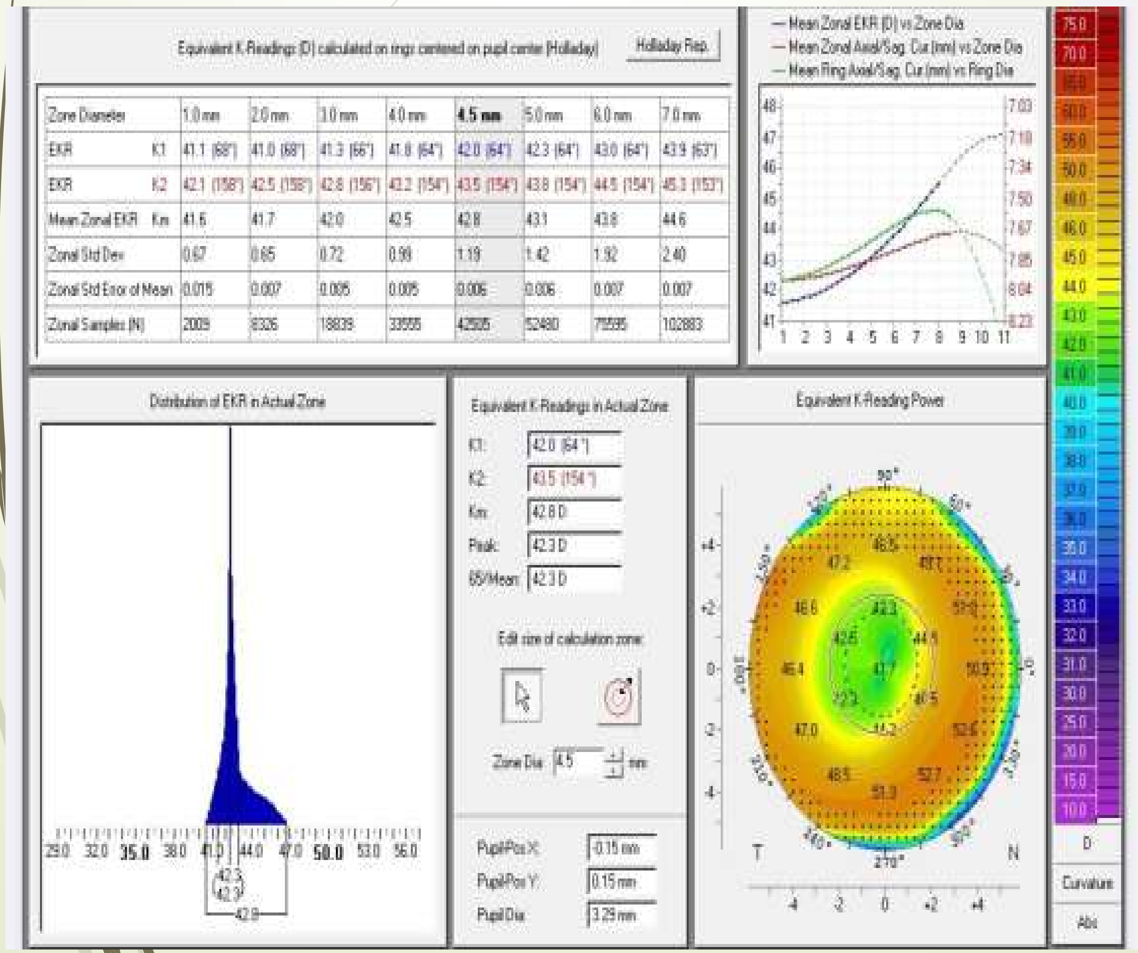
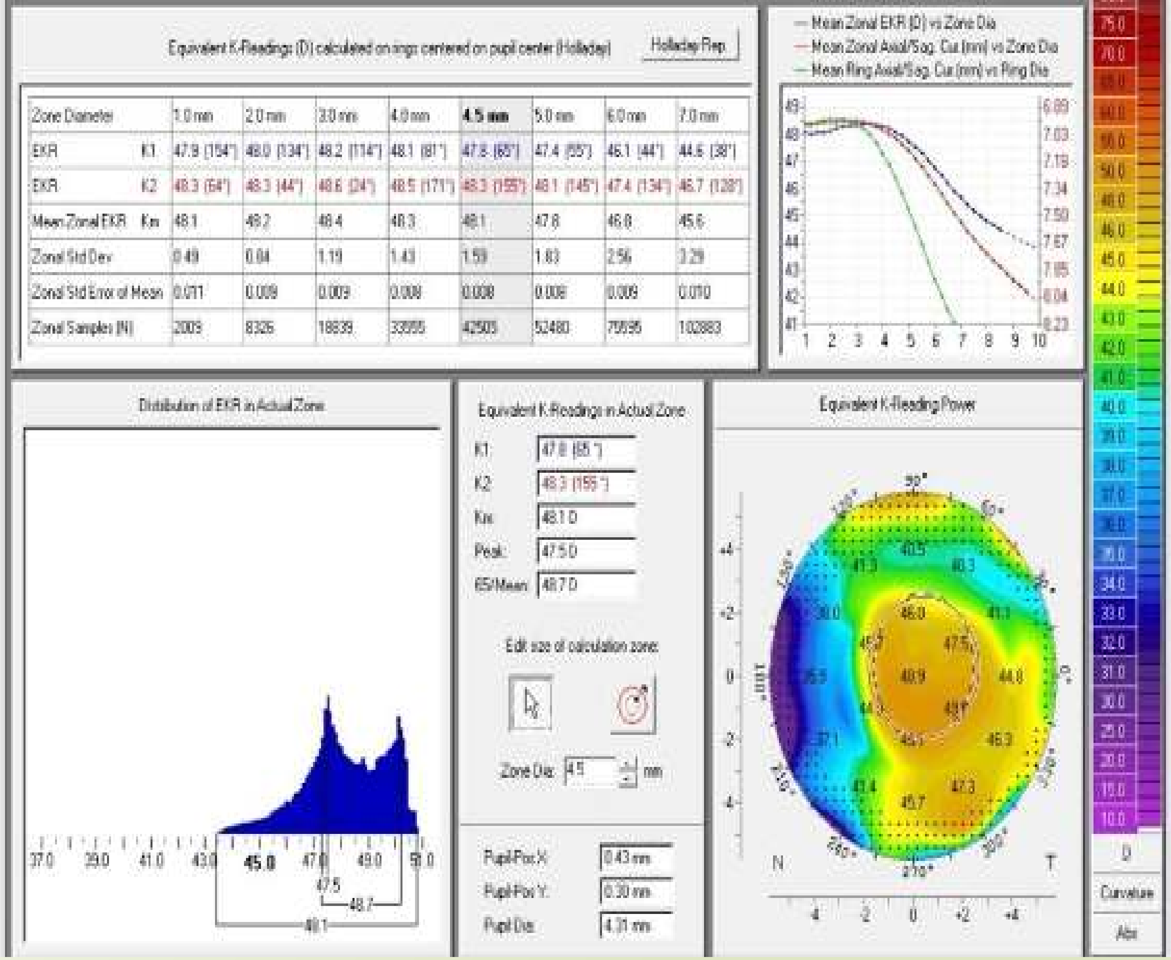
Trifocals allowable





Trifocals contraindicated

Post LVC
Aspheric IOLS

Hyperopic LASIK

-ve SA

May result in a net –ve SA

Cornea +ve SA
(+0.27)

Aspheric IOLS
-ve SA

Myopic LASIK

+ve SA

Can compensate SA

Post LVC
Aspheric IOLS

Must be customized

Aspheric IOLS

-0.27 Tecnis J&J

-0.2 Acrysof Alcon

Zero Envista Baush&lomb

+0.15 RayOneEMV Rayner

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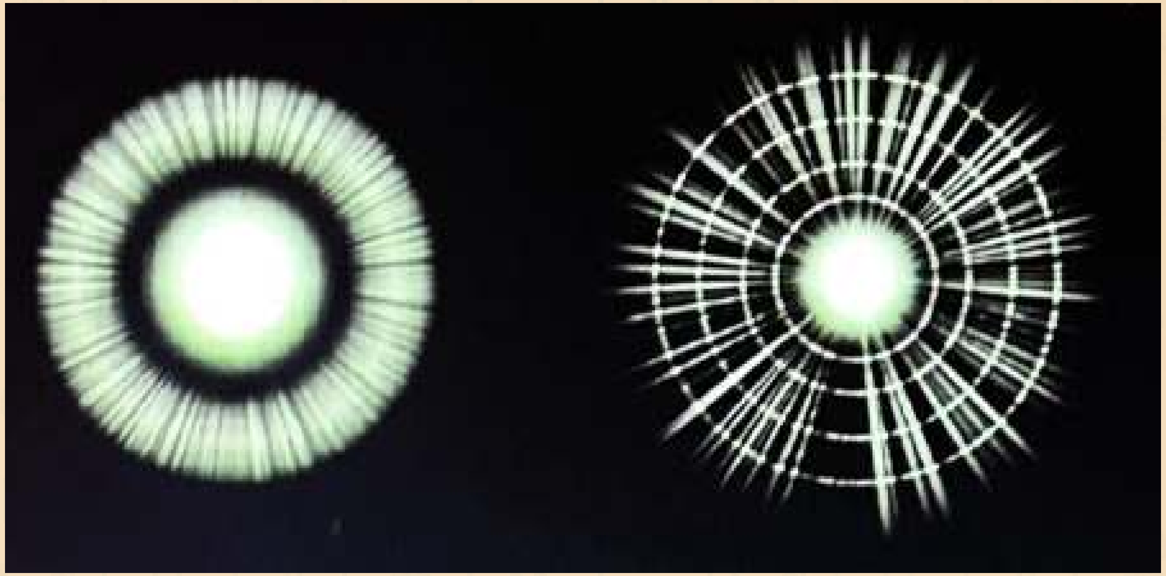
Presbyopia Correcting IOLs

Any diffractive technology induces halos, glares and degradation of the visual quality.
All efforts of manufacturers are to reduce these side effects.



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Alba-Bueno F, Vega F. Halos and multifocal IOLs; origin and interpretation. Arch Soc Esp. Opthalmol 2014, 89:397-404

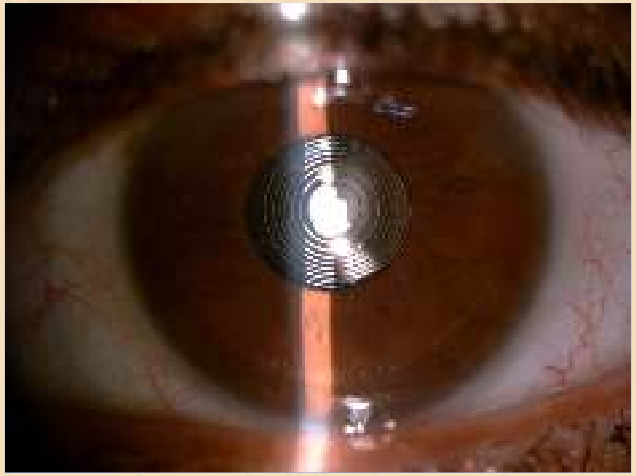
In my opinion the use of a diffractive technology Post LVC is full of challenges

-Increased halos

-Increased glare

-Degraded quality of vision

-Selection of asphericity is critical



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A better choice

EDOF intraocular lens

-EDOF intraocular lens induce much less halo and glare compared to diffractive IOL technology. It doesn’t split the light and has different technologies to induce an increase in the depth of field（ DOF）

EDOF intraocular lens may be beneficial post myopic LASIK

- In an interesting study it was shown that in post-LASIK eyes, the performance of the Vivity IOL is rather immune to the presence of HOAs and exhibits a quite constant DOF for a large range of corneal positive SA.

The Vivity IOL appears particularly suitable in post myopic LASIK surgery eyes.

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-Computational simulation of the optical performance of an EDOF intraocular lens in post-LASIK eyes. Carmen Met al. J cataract Refract surg 2023;49:1153-1159

EDOF & Halos

In post myopic LASIK with positive SA, halos with EDOF IOLS were smaller than the ones produced with monofocal IOLs.

RIO 2026

-Computational simulation of the optical performance of an EDOF intraocular lens in post-LASIK eyes.
Carmen Met al. J cataract Refract surg 2023;49:1153-1159

Open
LABORATORY SCIENCE

Computational simulation of the optical performance of an EDOF intraocular lens in post-LASIK eyes

2023

Carmen M. Lago, PhD, Alberto de Castro, PhD, Susana Marcos, PhD

Purpose: To evaluate computationally the optical performance of AcrySof IQ Vivity extended depth-of-focus (EDOF) intraocular lenses (IOLs) in post–laser in situ keratomileusis (LASIK) eyes.

Setting: Visual Optics and Biophotonics Laboratory, Madrid, Spain.

Design: Experimental study.

Methods: Computer pseudophakic eye models were implemented using reported post-LASIK corneal aberrations (refractive corrections from −7.5 to +4.5 diopters [D]) and virtually implanted with monofocal (AcrySof IQ) or EDOF (AcrySof IQ Vivity) IOLs. Retinal image quality was quantified through visual Strehl (VS). The depth of focus (DOF) was calculated from the through-focus VS curves. Halos were estimated from the light spread in the image of a pinhole. Those quantitative parameters were obtained for 5.0 and 3.0 mm pupil diameters.

Results: Simulated virgin eyes showed VS of 0.89/0.99 with monofocal IOLs and 0.74/0.52 with EDOF IOLs for 5.0/3.0 mm pupils at best focus. VS decreased with induced spherical aberration (SA) by 25% and with induced SA + coma by 61% on average (3.0 mm pupils). The DOF was 2.50 D in virgin eyes with EDOF IOLs, 1.66 ± 0.30 and 2.54 ± 0.31 D ($P < .05$) on average in post-LASIK eyes for 3.0 mm pupils, monofocal and EDOF IOLs, respectively. Halos were more sensitive to SA induction for 5.0 mm pupils, and induction of positive SA (myopic LASIK) resulted in reduced halos with the EDOF when compared with the monofocal IOLs, by 1.62 (SA) and 1.86 arc min (SA + coma), on average.

Conclusions: Computer post-LASIK pseudophakic eye models showed that the DOF was less dependent on the presence of SA and coma with EDOF IOLs and that halos were reduced with EDOF IOLs compared with the monofocal IOL for a range of SA.

J Cataract Refract Surg 2023; 49:1153–1159

Laser in situ keratomileusis (LASIK) is a well-known ocular treatment, with more than 30 years of evolution, which reshapes the cornea for the correction of refractive errors.[1] Typically, an excimer laser is used to ablate the cornea following an ablation profile such that the central cornea is flattened in myopic LASIK or steepened with respect to the periphery in hyperopic LASIK. Although the theoretical Munnerlyn algorithm does not necessarily induce higher-order aberrations (HOAs), approximations of this algorithm, discrepancies due to laser efficiency losses on a curved surface, and ablation plume shielding caused the induction of spherical aberration (SA) and coma, especially with larger corrections.[2–7]

Several studies in the early 2000s reported a change in corneal asphericity and an associated increase in the magnitude of SA after LASIK.[8–11] Particularly, 2 works by our group reported an induction of positive SA after myopic LASIK and an induction of negative SA after hyperopic LASIK.[3,4] The induction of corneal SA in the anterior surface of the cornea was proportional to the magnitude of the spherical correction and was obtained from the data obtained in patients operated with the Bausch & Lomb, Inc., Technolas 217-C laser (wavelength 193 nm, pulse repetition rate 50 Hz, and a peak radiant exposure of 120 mJ/cm^2).[3,4] The studies also showed increased coma, although its magnitude was not statistically significantly correlated with the preoperative spherical error.[5] In later studies, we showed through both computational simulations of the ablation process and experimental measurements that a large percentage of the induction of SA could be explained by the ablation efficiency loss in the periphery because of the non-normal incidence.[6,7]

Many patients who underwent LASIK surgery in the 2000s are in need of cataract surgery today. The presence of an early LASIK surgery has posed challenges in the

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Problems Post LVC

Conclusion

1-Eccentric ablation → *higher order aberrations most important vertical coma*

2-Induction of Spherical aberrations

Myopic lasik → *Positive Sph. Aberrations*

Hyperopic lasik → *Negative Sph. Aberrations.*

3-The optical zone treated is a factor in halos and glare seen by patients.

4-The pupil size is a determinant for the amount of aberrations seen by patients especially by night.

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“In post LASIK cases, the choice of Functional Vision IOLs is critical.”

- We have to understand the corneal aberrations and notice the pupil size to <u>customize</u> IOL selection.

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Thank You