
Barrett / Wolfe Lecture 2025
Past, Presence and Future of Presbyopia-Correcting IOLs
Michael C. Knorz
- Medical Faculty Mannheim, University of Heidelberg, Germany
- EuroEyes International Eye Clinics Ltd., Hongkong
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Early Multifocal IOL Designs
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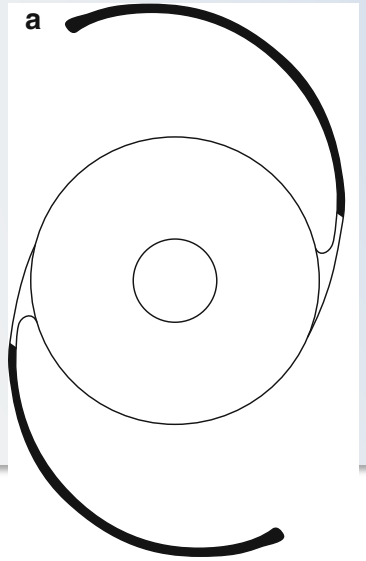
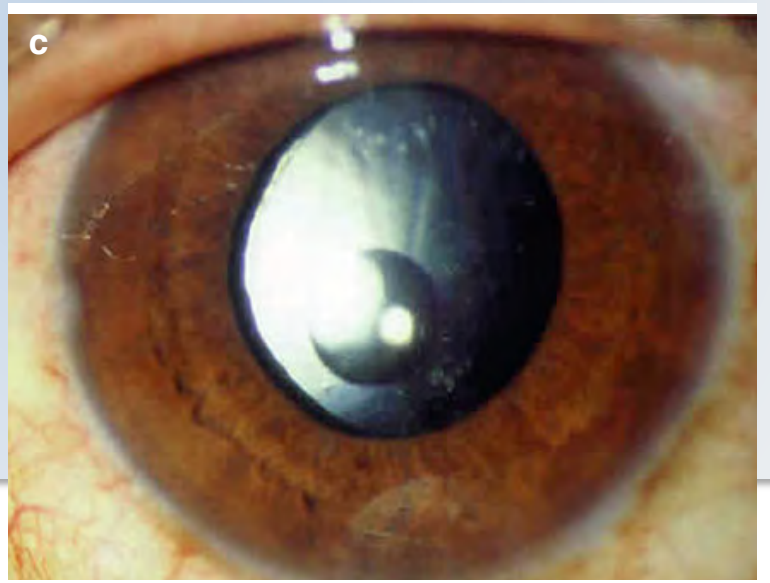
First Bifocal IOL

- First human implant was done by John Pierce in 1986
- „Bulls Eye“: Central near zone (Iolab NuVu IOL)





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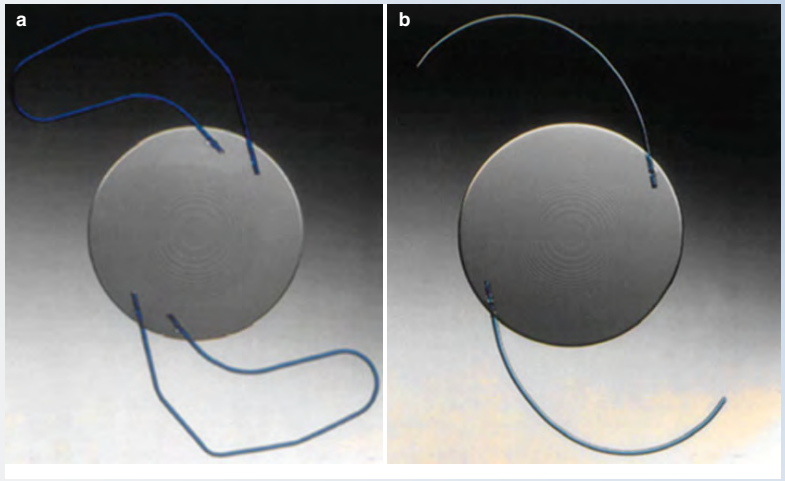
3M Diffractive Bifocal IOL

- FDA study started 1987 by Richard Lindstrom
- First MIOL I implanted



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My Academic Career started with MIOLs !

- Board-certified in ophthalmology 1989
- Research on multifocal IOLs 1989-1993
- MIOL were topic of my habilitation (qualification for professorship) 1993
- Professor of Ophthalmology in 2000

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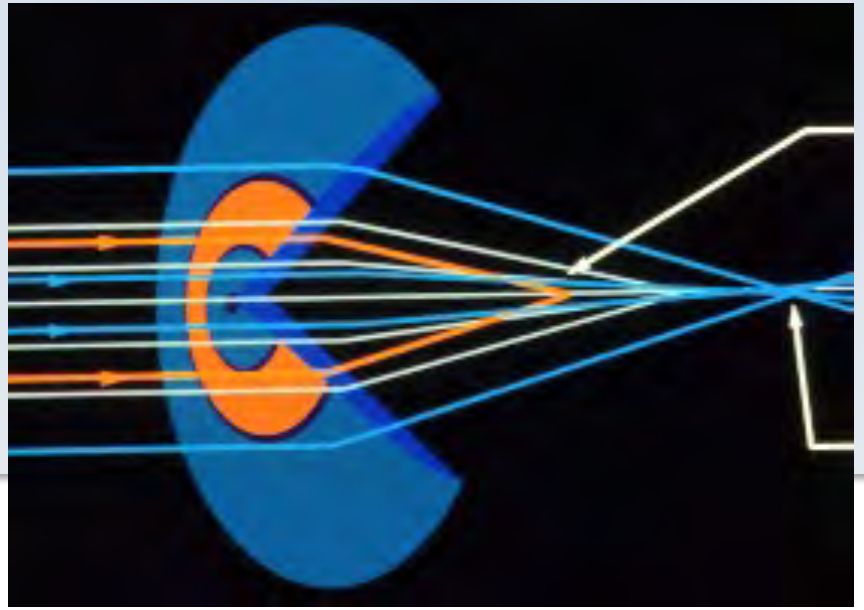
True Vista MIOL (Storz, St. Louis)

- 3-zone refractive MIOL
- I participated in the European Multicenter Study 1990



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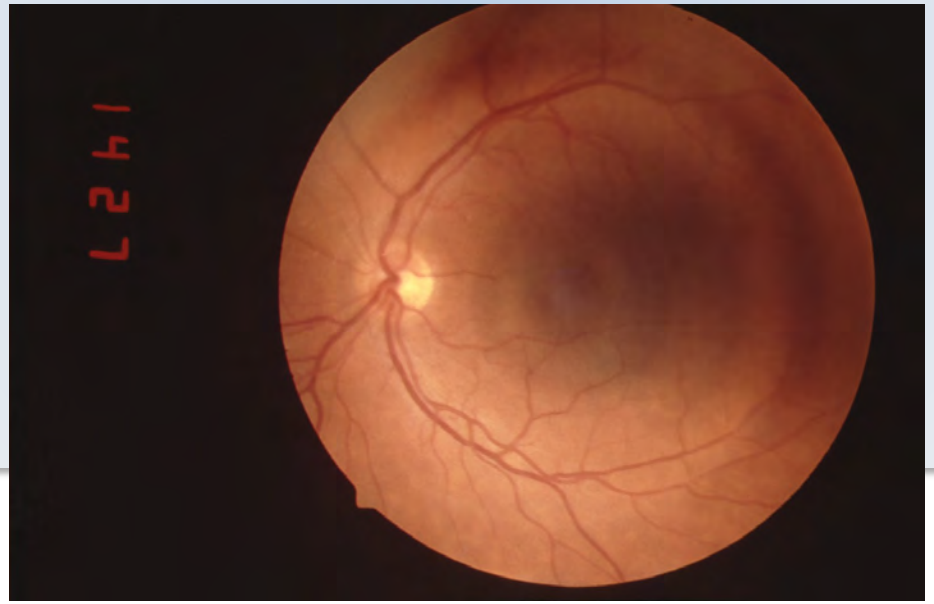
AcuraSee MIOL (Alcon, Ft. Worth)

- 3-zone refractive MIOL
- I participated in the European Multicenter Study 1991



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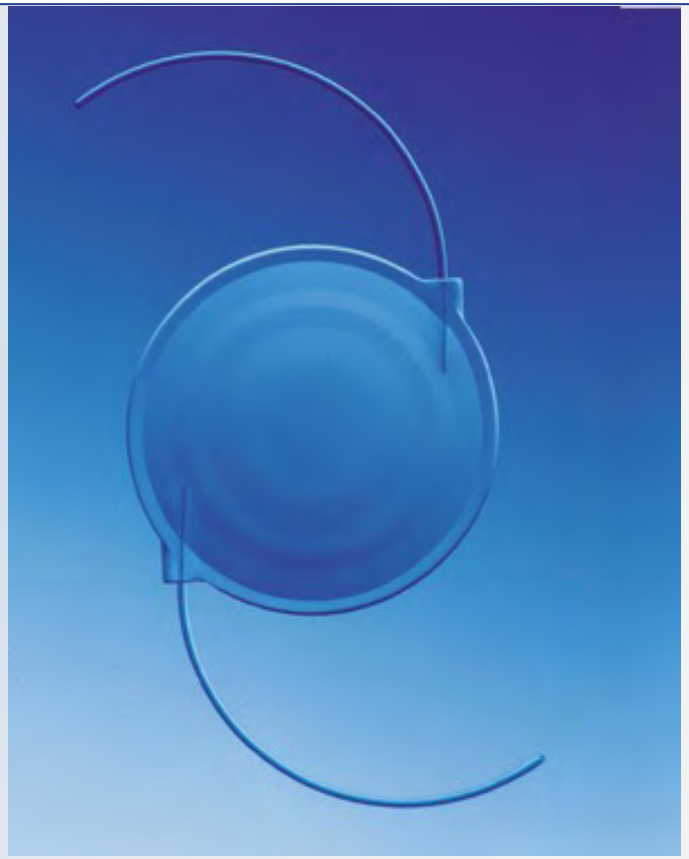
Array MIOL (AMO)

- 5-zone refractive MIOL
- I participated in the European Multicenter Study 1993
- First FDA-approved MIOL (1997)
- First foldable MIOL
- More than 200,000 IOLs implanted



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My Research on Multifocal IOLs

- Lab research with Storz in St. Louis
  - Modulation transfer function (MTF)
  - Through-Focus-Response (TFR)
  - Defocus curves
- Clinical research in Mannheim, Germany
  - Visual acuity
  - Contrast sensitivity
  - Defocus curves
- I correlated lab data and clinical data

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I wrote a thick book on MIOLs in 1993..

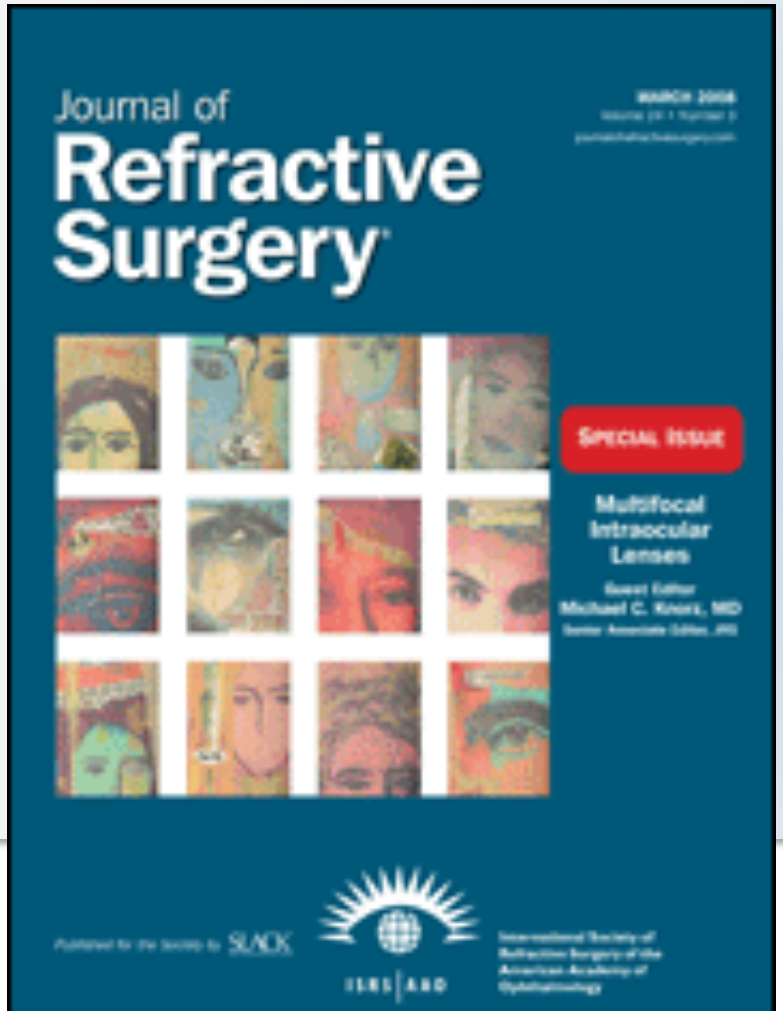
Aus der Augenklinik der Fakultät
für Klinische Medizin Mannheim
(Direktor: Prof. Dr. H. Liesenhoff)

UNTERSUCHUNGEN ZUM SEHVERMÖGEN MIT BIFOKALEN INTRAOKULARLINSEN

Habilitationsschrift
zur
Erlangung der Venia legendi für das Fach Augenheilkunde
der
Fakultät für Klinische Medizin Mannheim
der
Ruprecht-Karls-Universität
zu
Heidelberg

vorgelegt
von
Dr. Michael C. Knorz
aus
Mannheim
1993

15 Years later I edited a JRS Special Edition on MIOL



March 2008

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Membership IIIC in 1999

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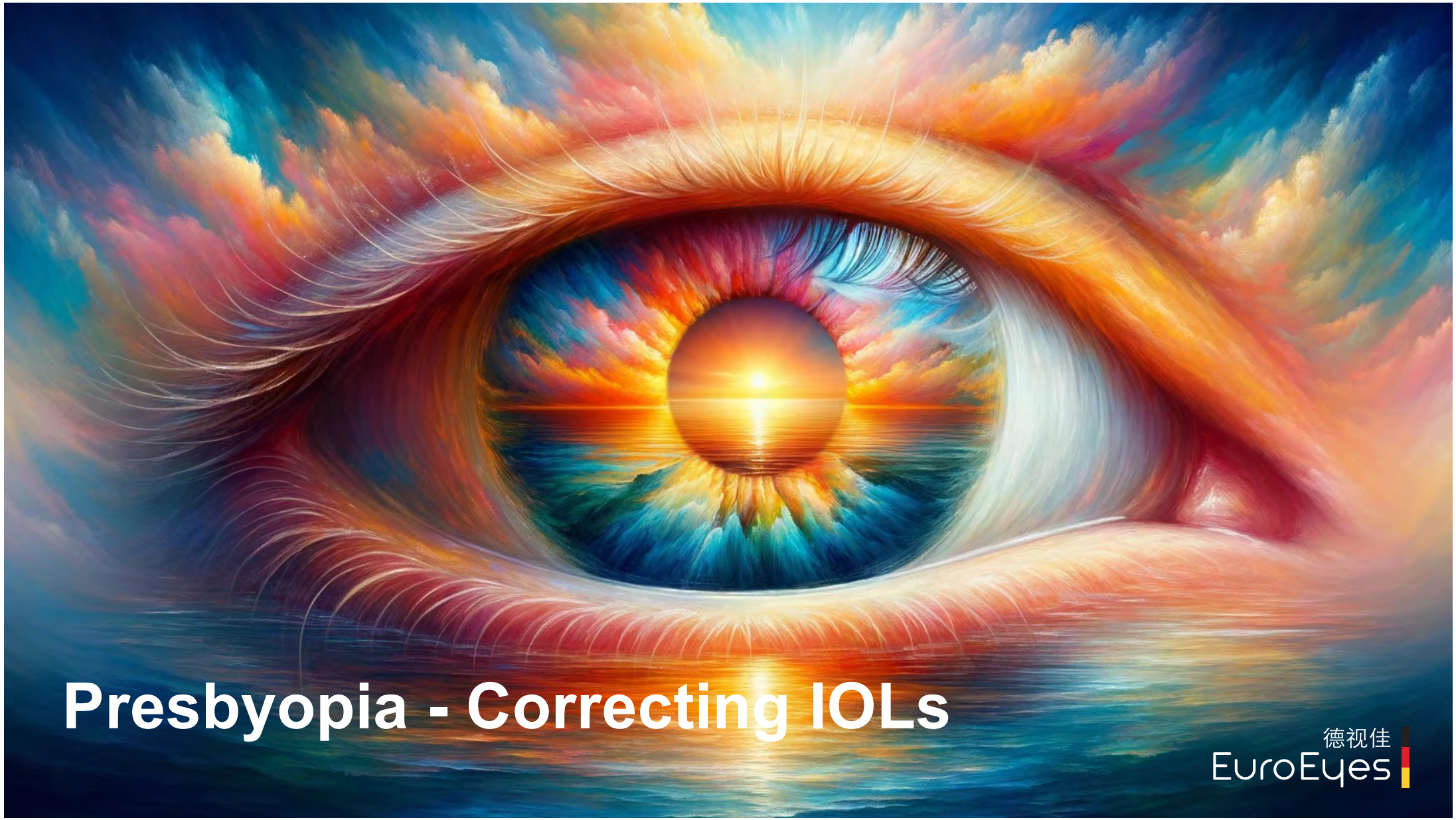
Presbyopia - Correcting IOLs
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Presbyopia – Correcting IOLs

- Extended Depth of Focus (EDoF) IOLs
  - Diffractive or **Refractive** (spherical aberration)
  - Provide about **1.5 D** of near add
  - Few optical side effects (halo, glare)
  - Patients still need reading glasses

- Multifocal / trifocal „full-range-of-vision“ IOLs (MIOL)
  - Refractive or **Diffractive**
  - Provide about **3 D** of near add
  - Significant optical side effects
  - No glasses at all

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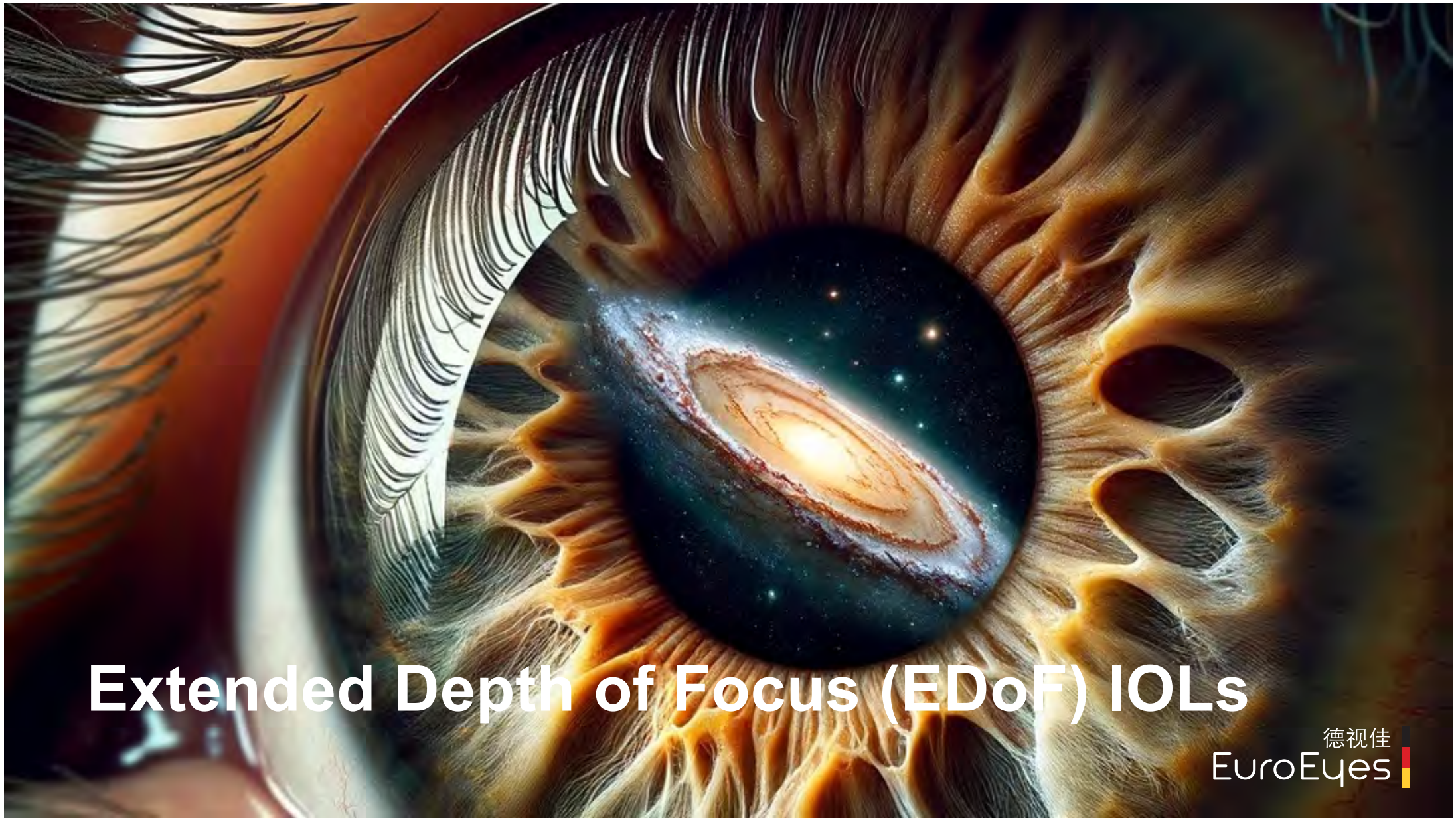
Extended Depth of Focus (EDoF) IOLs
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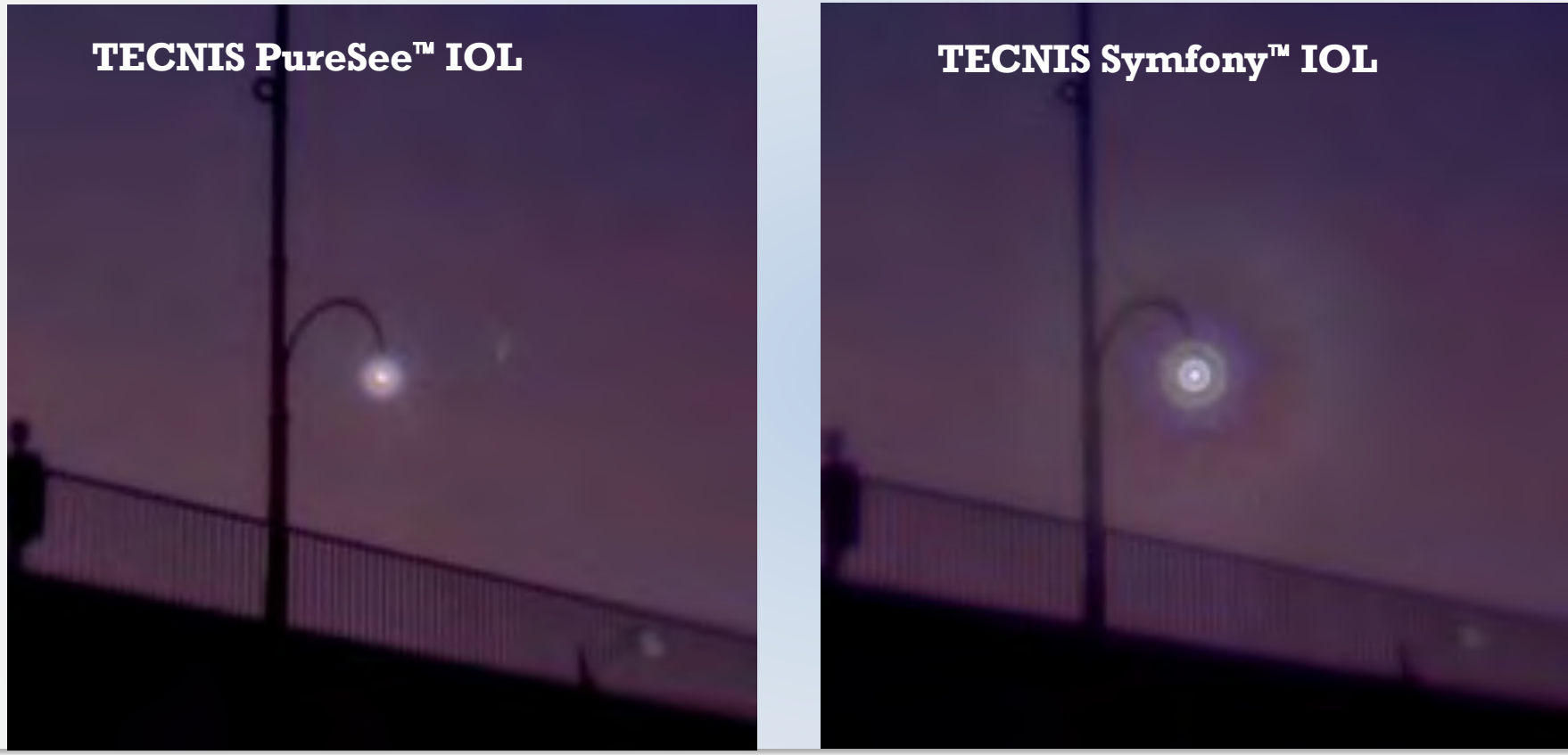
Extended Depth of Focus (EDoF) IOLs

- Diffractive EDoF
  - Symphony IOL (AMO) first FDA-approved EDoF, 2016
  - Zeiss AT LARA

- **Refractive EDoF**
  - Vivity (Alcon)
  - RayOne EMV (Rayner)
  - TECNIS PureSee (J&J)

EDoF: Refractive vs Diffractive: ***Less Halos !***



Courtesy Johnson&Johnson Vision

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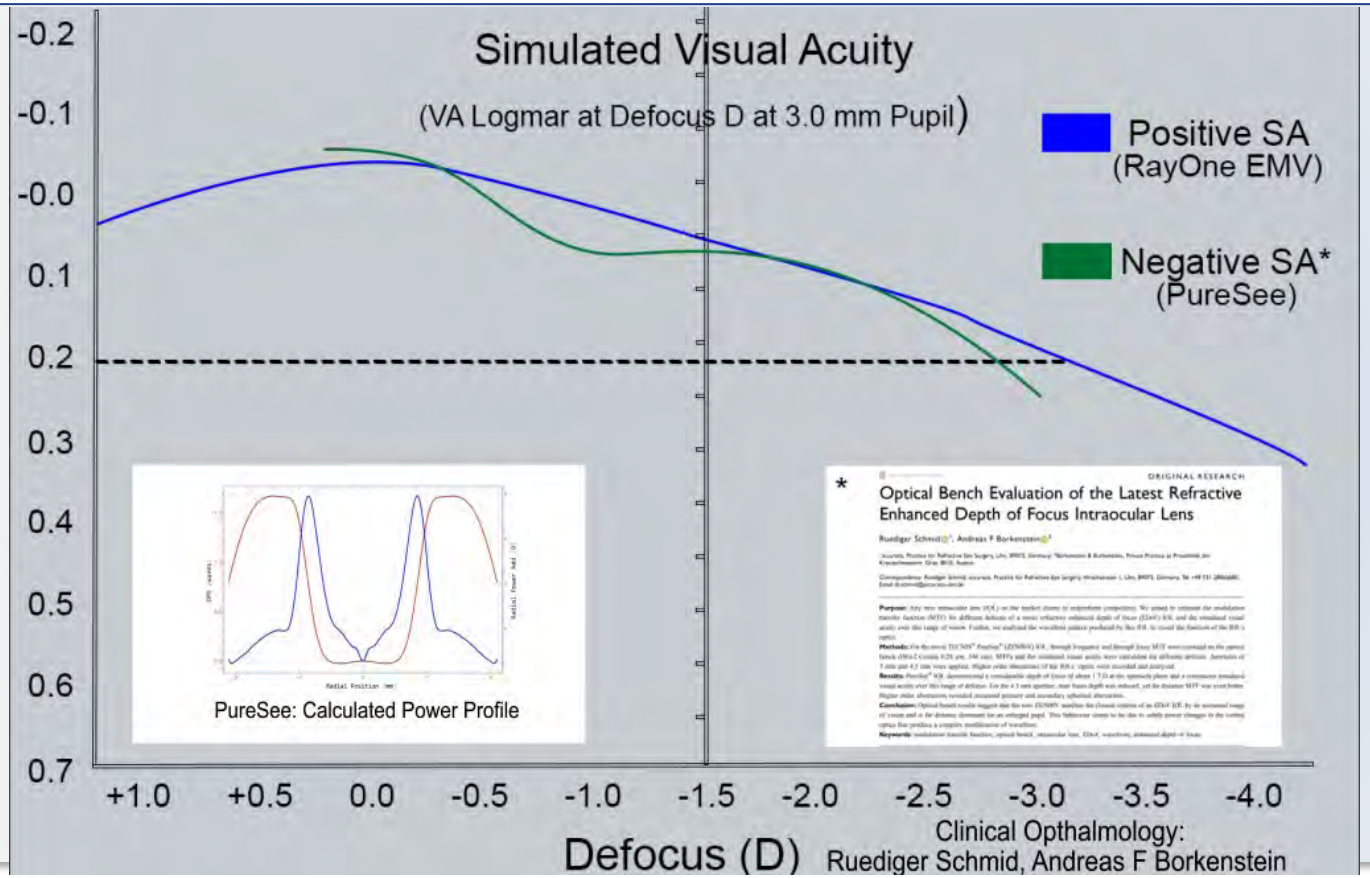
TECNIS PureSee vs Rayner RayOne EMV



Courtesy Graham Barrett

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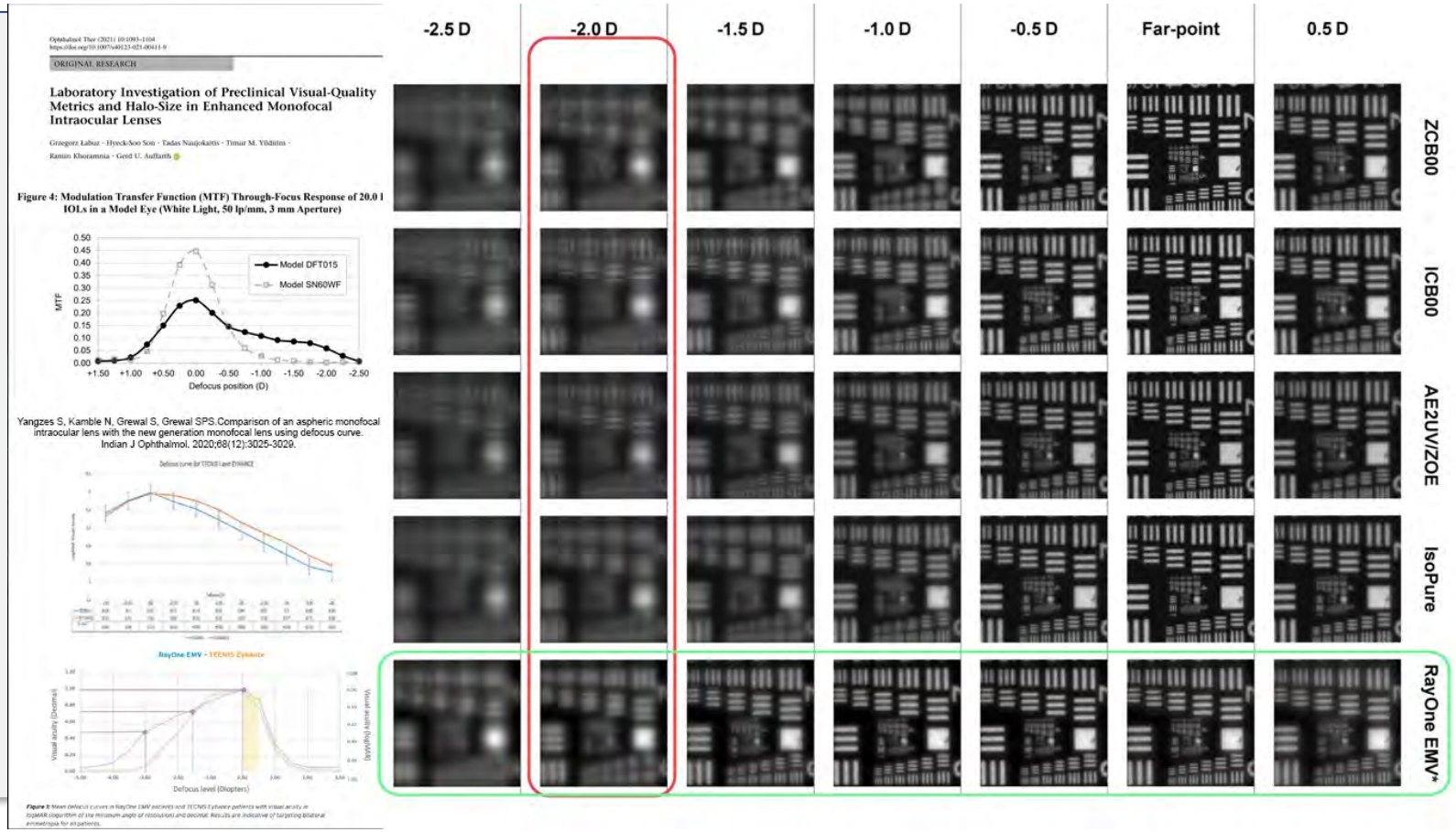
Rayner RayOne EMV vs Monofocal



Courtesy Graham Barrett

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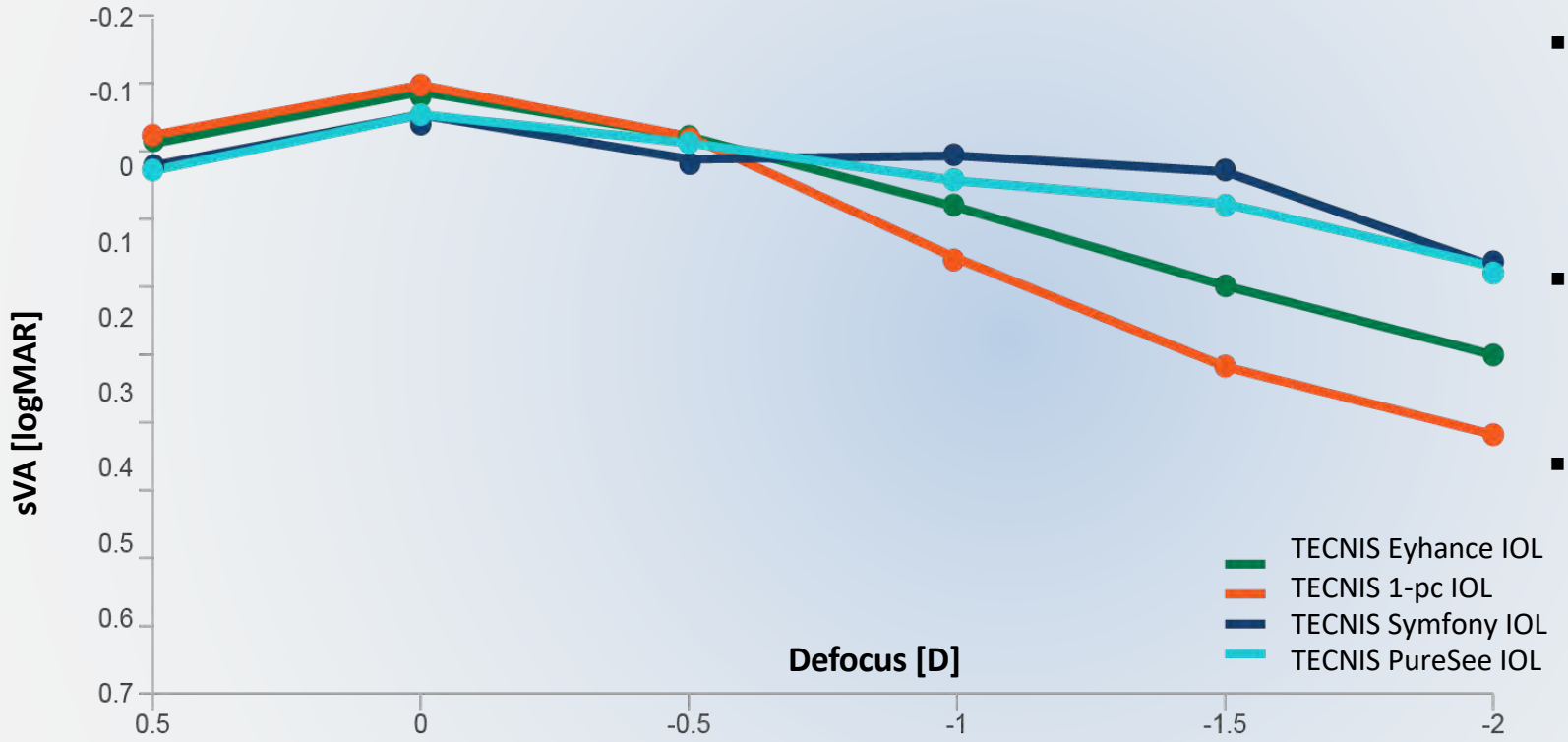
TECNIS PureSee EDoF



TECNIS PureSee™ IOL:

- ~ 2 lines improvement at intermediate and near compared to „enhanced monofocal“
- Less than ½ line difference at distance compared to monofocal
- Similar to diffractive EDOF, but almost no halos

Courtesy Johnson&Johnson Vision

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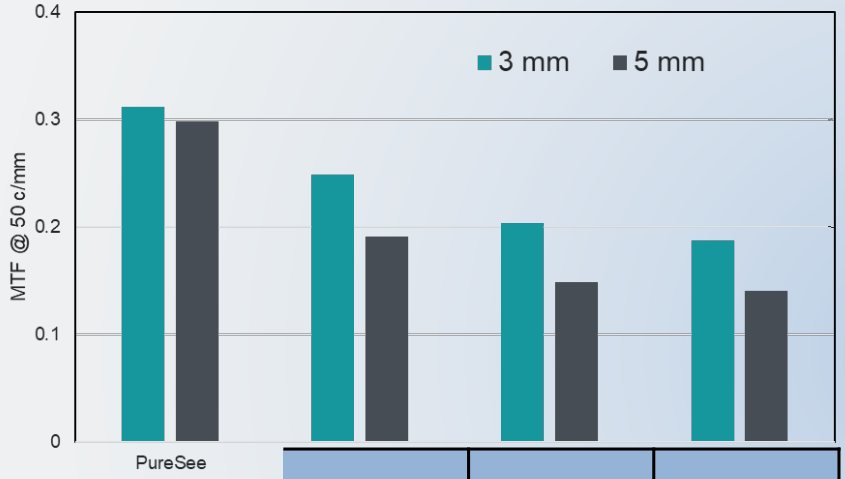
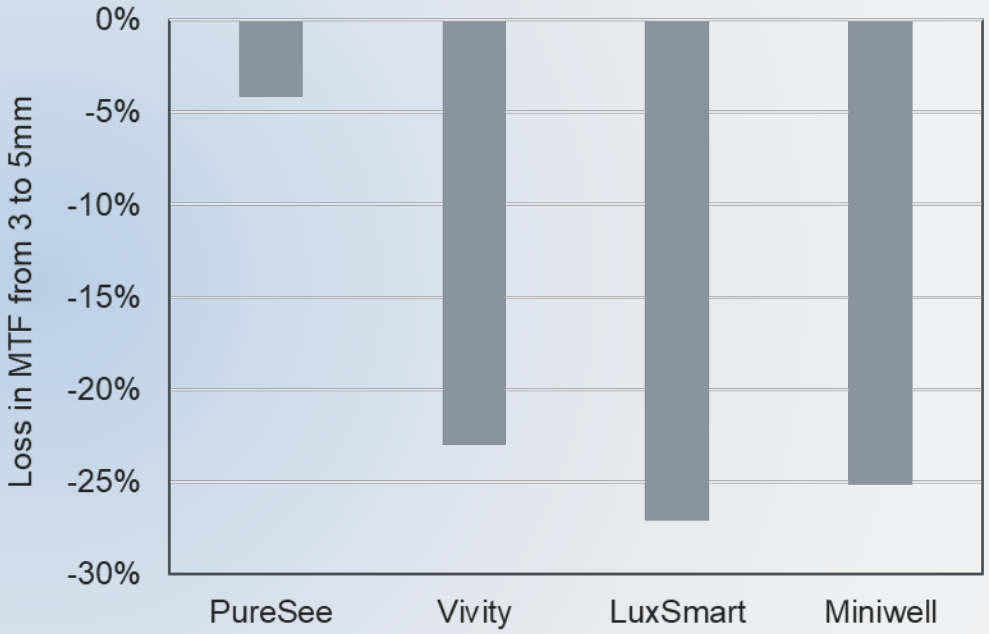
TECNIS PureSee EDoF – MTF and Contrast

Image contrast at distance



		PureSee	Vivity	LuxSmart	Miniwell
MTF Differenz zur DEN00V	3mm		-20 %	-35%	-40 %
	5mm		-36 %	-51%	-53 %

Relative MTF reduction with increasing pupil size (3mm to 5mm)



Courtesy Gerd Auffarth

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Multifocal / Trifocal „full range of vision“ IOLs
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Multifocal / Trifocal IOLs (MIOL)

- Diffractive MIOL
  - ReSTOR +3 MIOL (Alcon), 2005 (more than 900,000 implanted)
  - PanOptix (Alcon), 2019
  - TECNIS Odyssey (J&J), 2023
  - AT LISA TRI IOL (Zeiss)
  - FineVision IOL (BVI Medical)

- Refractive MIOL
  - Array (1997) and ReZOOM (2005), both AMO
  - Rayner RayOne Galaxy (2024)

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Clinical Results with Zeiss AT LISA Trifocal IOLs

- EuroEyes has implanted > 60,000 Zeiss AT LISA TRI

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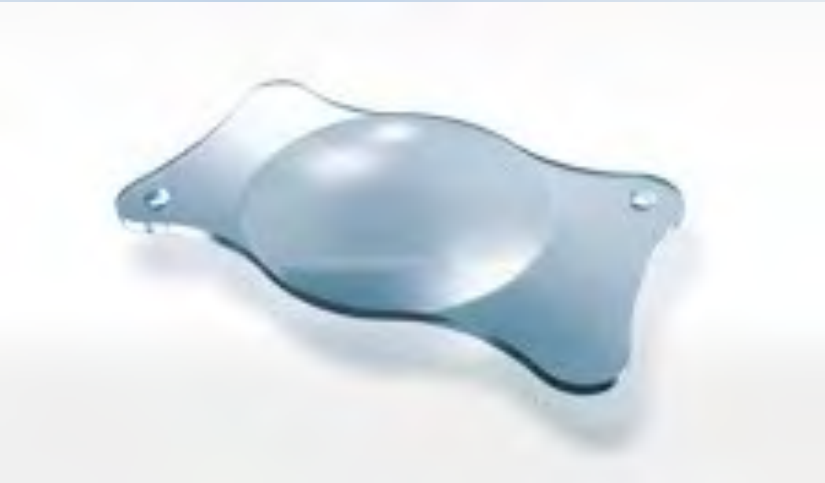
EuroEyes Clinical Data - Refractive Lens Exchange

- 3,842 eyes (1,921 patients) in 2017 + 2018
- Mean SE -0.6 D (-20 D to +12 D)
- 5 surgeons

- 2,212 eyes (58%) 6-months follow up



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EuroEyes Data - Patient Satisfaction

- Satisfied: 95 % (1,819 patients)

- Not satisfied after initial surgery: 5 % (102 patients)
  - **Residual refractive error: 4.5 % (88)**
  - Optical side-effects of trifocal IOL: 0.5 % (14)

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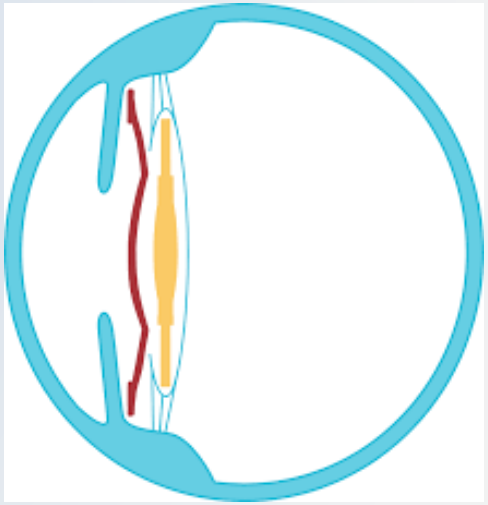
How to Handle Unhappy Patients ?

- Most important: TALK !! Show EMPATHY !
  - Explain that it takes time to get used to halos
  - Explain that halos show „that the IOL works“
  - Explain that residual refractive errors can be treated
  - Correct residual errors with CL or glasses until they can be treated

  - Treat residual refractive errors after 3 – 6 months

How to Treat Residual Refractive Error ?

- Limbal Relaxing Incisions (LRI)
  - Fast and easy
- Add-on IOL
- LASIK or PRK
  - Avoid in dry eyes



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Persistent Optical Side - Effects of Trifocal IOLs

- Persistent optical side effects are rare
  - 0.5 % of patients only
- IOL exchange for monofocal or EDoF IOL is an option
  - Not before 6 months after surgery
- We observed an exchange rate of 0.05% (1 of 1,921)

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IOL Exchange: My Recommendations

- **Dominant eye should be exchanged first !**
  - Dominant eye should be corrected for distance

- Demonstrate reading vision with dominant eye only
  - Patients will be unable to read with dominant eye only

Most patients will prefer to keep the MIOL in the other eye for reading !

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What about YAG – Laser ?

Patient unhappy and capsular opacification visible:
What shall we do ?

- If patient was initially happy after surgery:
  - Perform YAG - Laser capsulotomy early

- If patient was complaining from day 1:
  - DO NOT PERFORM YAG, but exchange MIOL !


Comparison of EDoF and MIOL
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Optics - EDoF vs MIOL

- Extended Depth of Focus (EDoF) IOLs
  - ***Refractive optic (spherical aberration)***

- Multifocal / trifocal „full-range-of-vision“ IOLs (MIOL)
  - ***Diffractive optic***

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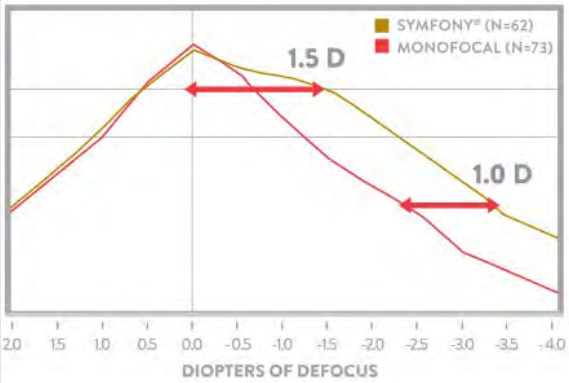
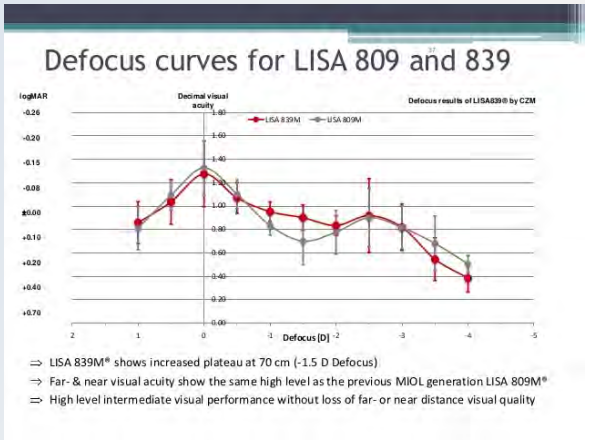
Near Add - EDoF vs MIOL

- Extended Depth of Focus (EDoF) IOLs
  - Refractive optic (spherical aberration)
  - ***Provide about 1.5 D of near add***

- Multifocal / trifocal IOLs (MIOL)
  - Diffractive optic
  - ***Provide about 3 D of near add***





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Optical Side Effects – EDoF vs MIOL

- Extended Depth of Focus (EDoF) IOLs
  - Refractive optic (spherical aberration)
  - Provide about 1.5 D of near add
  - ***Few optical side effects (halo, glare)***

- Multifocal / trifocal IOLs (MIOL)
  - Diffractive optic
  - Provide about 3 D of near add
  - ***Significant optical side effects***

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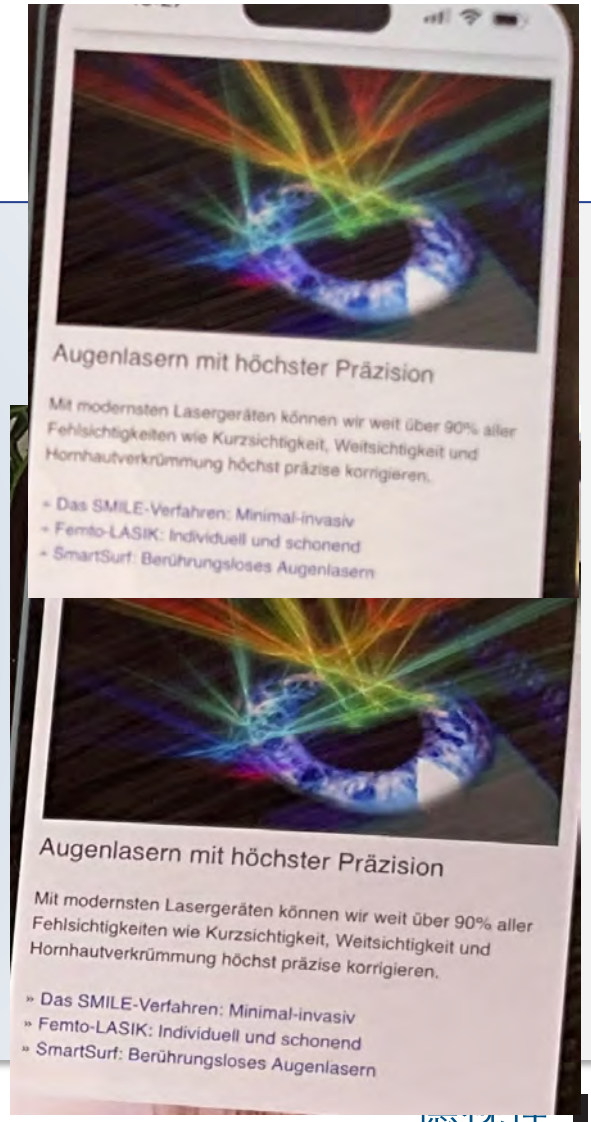
Need for Glasses – EDoF vs MIOL

- Extended Depth of Focus (EDoF) IOLs
  - Refractive optic (spherical aberration)
  - Provide about 1.5 D of near add
  - Few optical side effects (halo, glare)
  - ***Patients still need reading glasses***

- Multifocal / trifocal IOLs (MIOL)
  - Diffractive optic
  - Provide about 3 D of near add
  - Significant optical side effects
  - ***No glasses at all***



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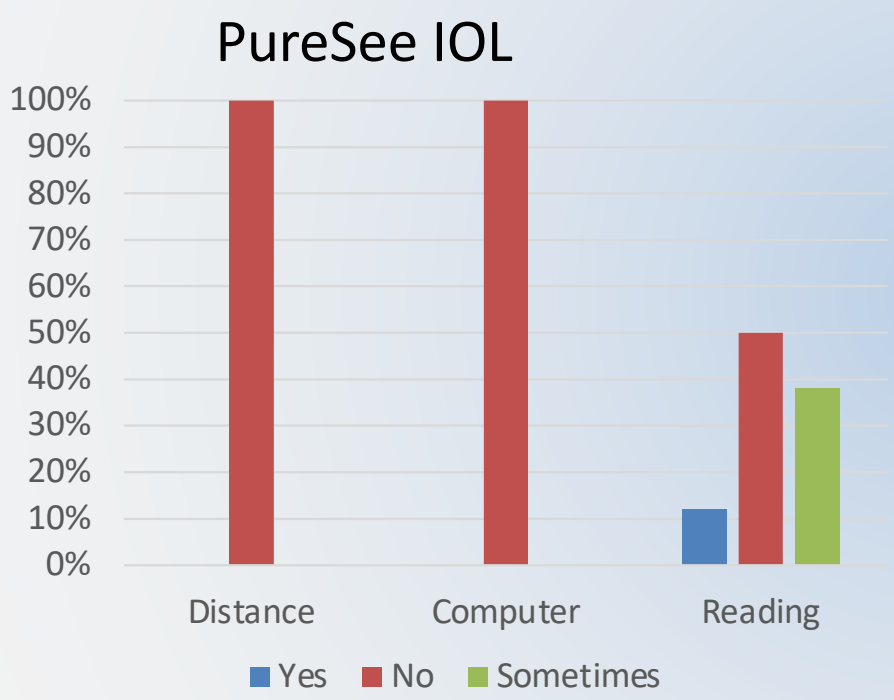
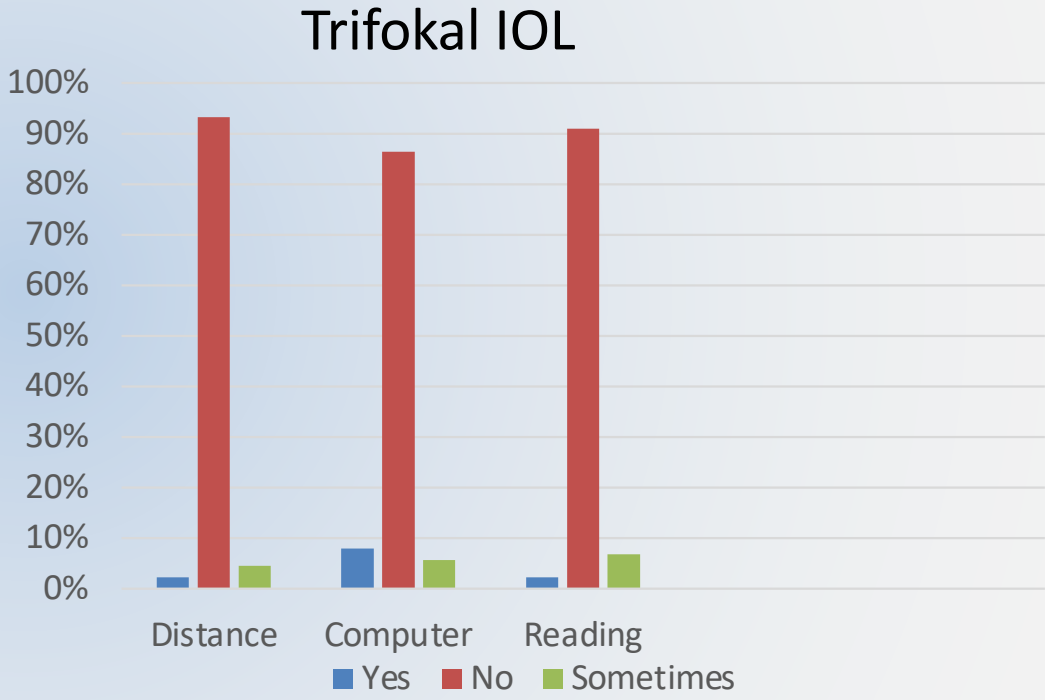
Clinical Results - PureSee EDoF vs Zeiss Trifocal

Do you need glasses at distance, intermediate or near ?





Courtesy Jannik Boberg-Ans

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What can Patients expect ?

- Extended Depth of Focus (EDoF)
  - Excellent distance and good intermediate vision (laptop)
  - Few optical side effects
  - Reading glasses frequently required

- Multifocal / trifocal IOLs (MIOL)
  - Good distance, intermediate and near vision
  - Significant optical side effects
  - Small risk of IOL exchange (0.05%)
  - No glasses at all !

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EDoF

MIOL


Unser LASIK Zentrum - Unser Team
Gegründet 1993
Im Jahr 1993 gründete Prof. Dr. Michael Knorz an der Universitäts-Augenklinik Mannheim das erste deutsche LASIK Zentru
1999 das FreeVis LASIK Zentrum Universitätsklinikum Mannheim hervorging. Seitdem haben wir uns auf die operative Korr
Kurzsichtigkeit, Weitsichtigkeit, Hornhautverkrümmung und Alterssichtigkeit (Presbyopie) spezialisiert und bieten das kompl
der derzeit zur Verfügung stehenden Methoden an.
"Unser Ziel ist es, auf hohem medizinisc
und technischen Niveau
die Freiheit des Sehens
für den Einzelnen zu ermöglichen."
Prof. Dr. med. Michael
15:27
Augenlasern mit höchster Präzision
Mit modernsten Lasergeräten können wir weit über 90% aller Fehlsichtigkeiten wie Kurzsichtigkeit, Weitsichtigkeit und Hornhautverkrümmung höchst präzise korrigieren.
» Das SMILE-Verfahren: Minimal-invasiv
» Femto-LASIK: Individuell und schonend
» SmartSurf: Berührungsloses Augenlasern
HIGHWAY
WEST
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» Das SMILE-Verfahren: Minimal-invasiv
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» SmartSurf: Berührungsloses Augenlasern
HIGHWAY
WEST


Modern Presbyopia - Correcting IOLs
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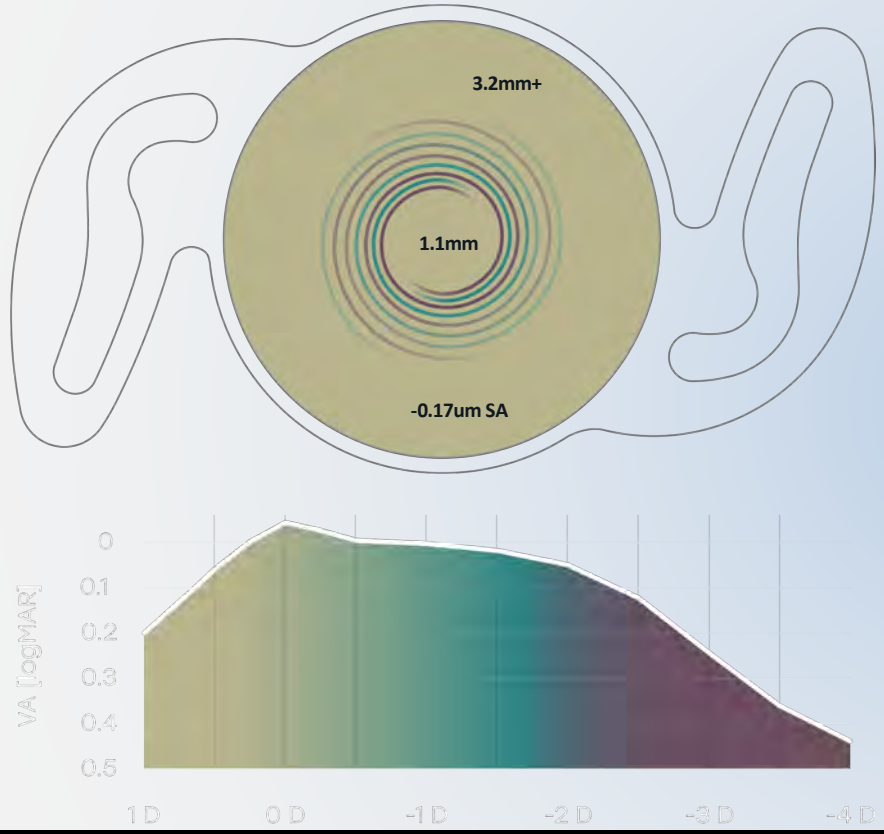
The Spiral IOL | Designed with AI



- **A proprietary AI engine** created a unique optical spiral tuned for optimal patient outcomes.
- Spiral tracks allow **continuous variance of power, focusing light at every position along the defocus curve.**
- Results in **precise control of the optical power** from far to near focus, producing a **smooth and continuous full range of vision**.
- The **smooth and continuously changing surface** with no abrupt transitions decreases dysphotopsia and light loss.

Rayner | GALAXY

Note: Spiral optic image is illustrative only

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Glare and Halos – Galaxy vs Diffractive

Galaxy (n=52)

	Halo	Glare
Size	26.2 ± 25.4	8.0 ± 15.2
Intensity	31.2 ± 31.3	10.8 ± 18.2

RayOne Galaxy halo and glare simulator at 1-month (n=52).
Rayner multicentre data collection

PanOptix (n=24)

	Halo	Glare
Size	39.3 ± 20.8	10.1 ± 14.5
Intensity	49.7 ± 21.9	21.7 ± 24.8

PanOptix, Alcon, at 3 Month (n=24).
Adapted from Lwowski C et al. J Refract Surg. 2023 Aug;39(8):510-517.
Based on Halo T1, as illustrated in paper.

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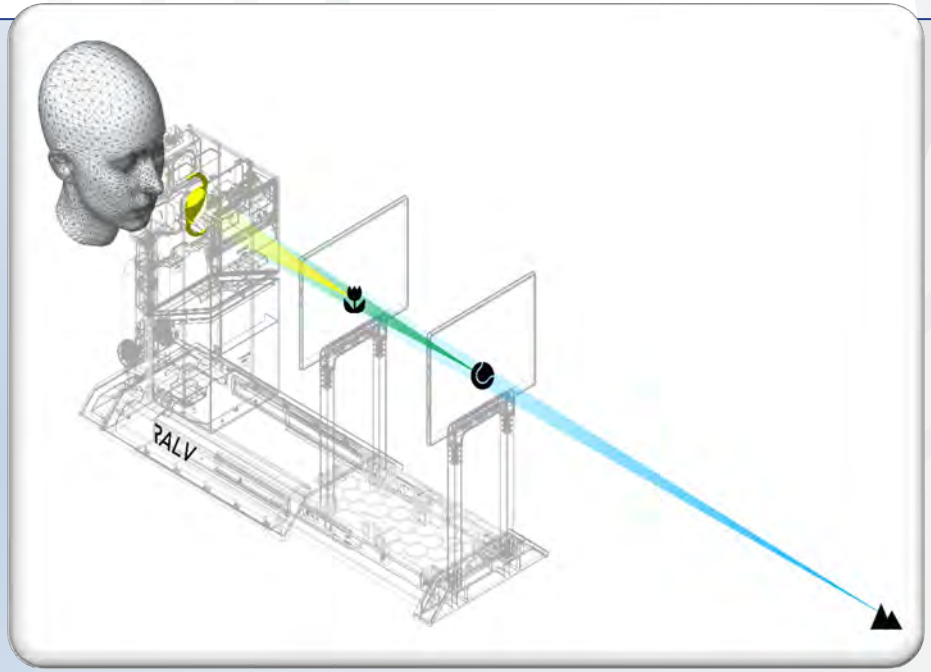
RALV (**R**eal **A**rtificial **L**ens **V**ision) | DEZIMAL GmbH

- **Demonstration** of achievable vision after implantation of an IOL.
- Main benefit: enables direct comparison of **multiple lens designs.**
- IOLs are inserted in the RALV Device:
  - realistic visual impression
  - IOLs tested without implantation



In collaboration with

Dr Wolfgang Brezna
ACMIT GmbH
Austrian Center for Medical Innovation and Technology

Prof Michael Amon
Assoc Prof Günal Kahraman
Barmherzigen Brüder Vienna Eye Clinic

Rayner | GALAXY

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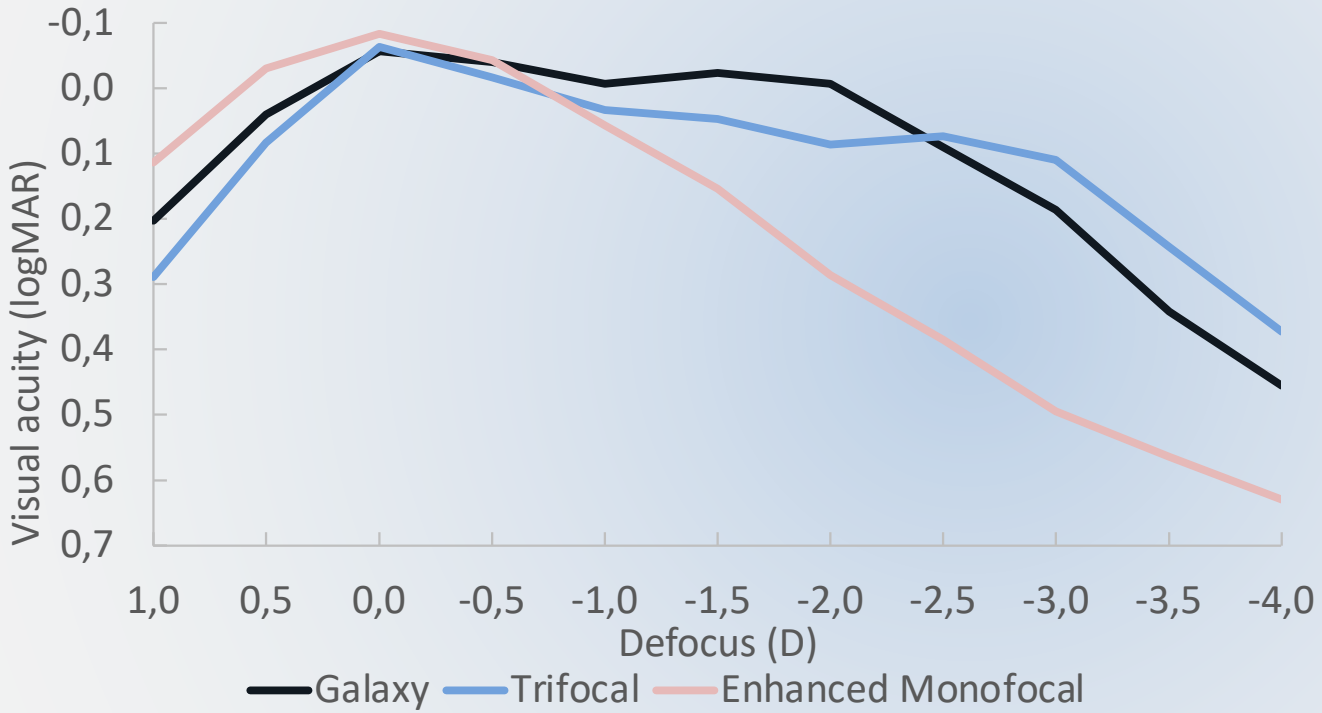
Defocus Curve Galaxy vs Trifocal vs Monofocal+



- **Excellent distance vision.**
- **Full range** of vision **comparable to a trifocal** IOL.
- **Better intermediate VA with smooth plateau between 0.0 D and -2.50 D for Galaxy** compared to trifocal IOL.

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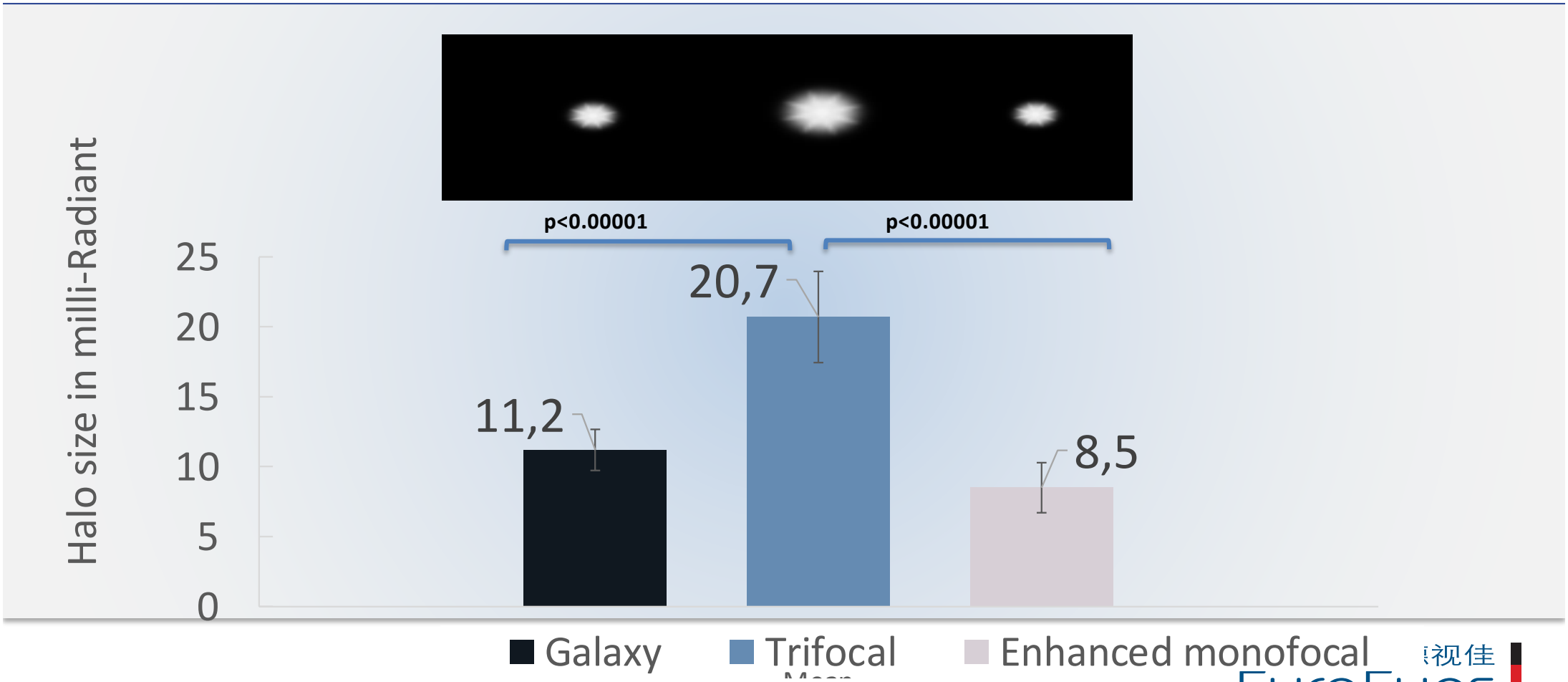
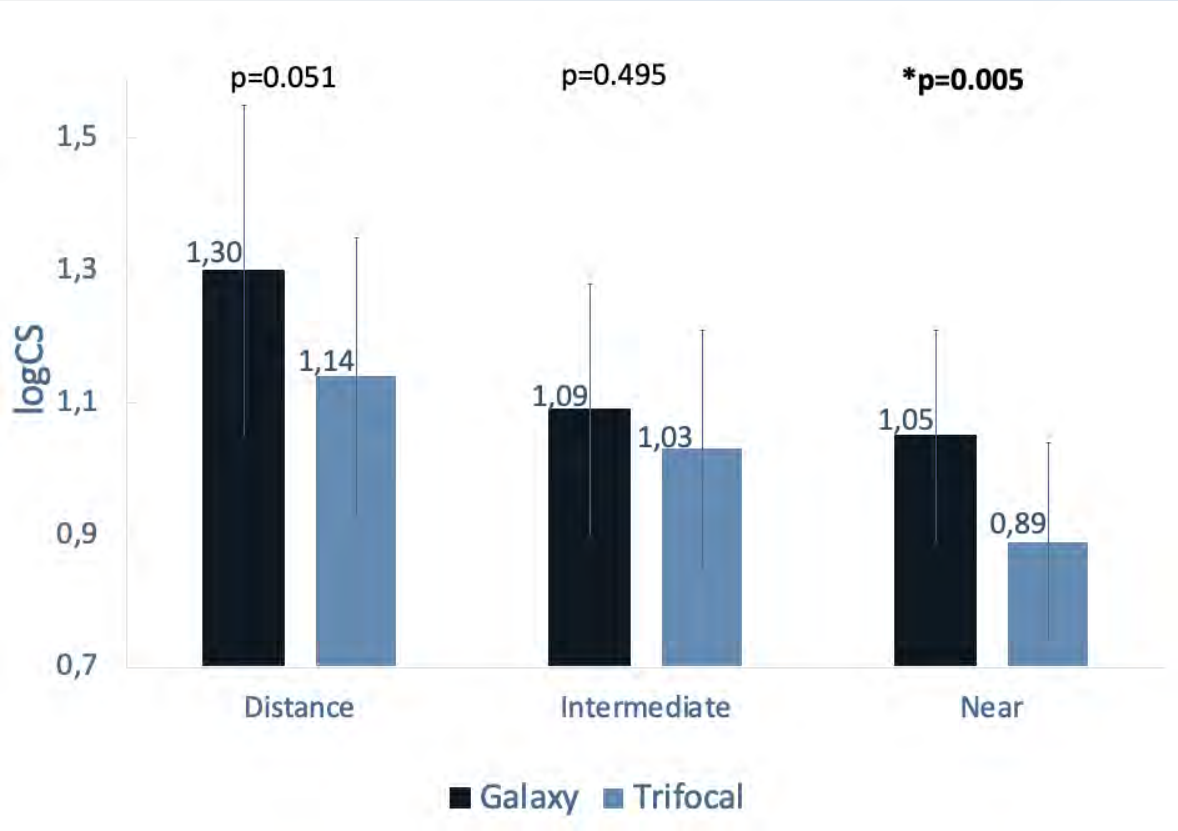
Halo Size Galaxy vs Trifocal vs Monofocal+



Contrast Sensitivity Galaxy vs Trifocal



The Galaxy spiral IOL demonstrated **better contrast sensitivity** compared to a diffractive trifocal IOL.

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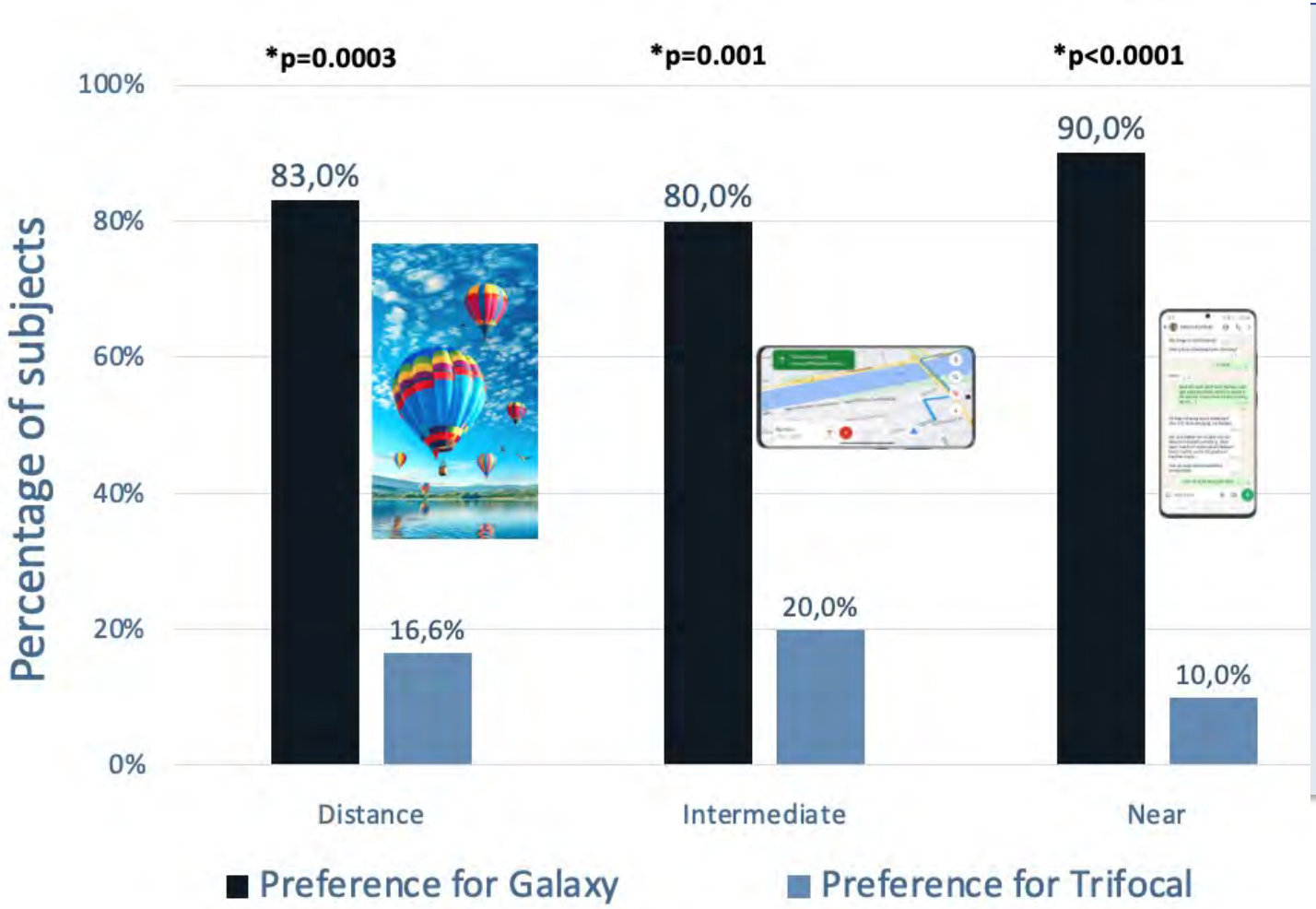
Subjective Preference Galaxy vs Trifocal



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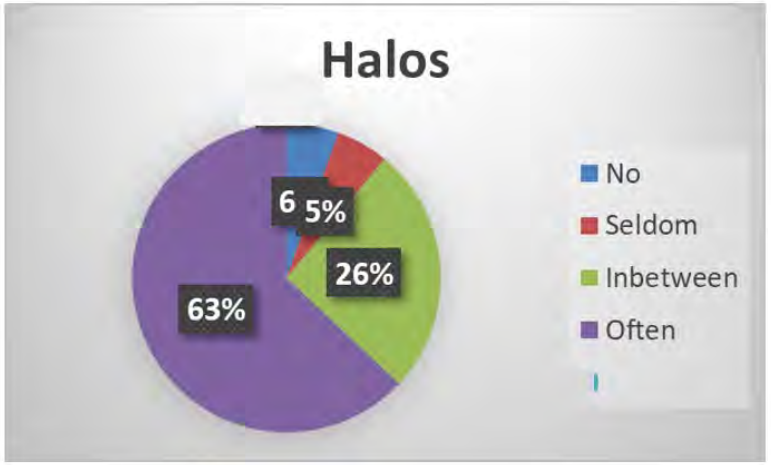
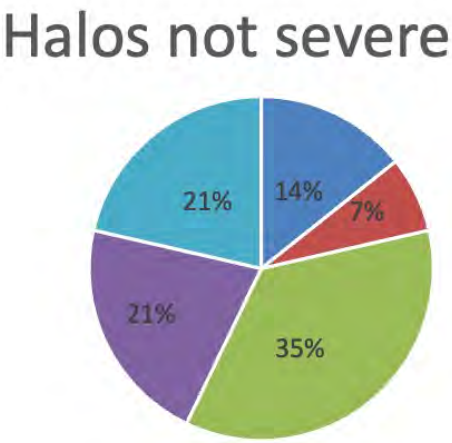
EuroEyes Data – Galaxy vs Zeiss AT LISA

Zeiss AT LISA TRI



Often or always 89%
6% No Halo

RayOne Galaxy



Often or always 42%
14% No Halo

Courtesy Jannik Boberg-Ans

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The World’s First Adjustable Intraocular Lens

Light Adjustable Lens

- Crystal clear silicone optic
- Photoreactive UV-absorbing material
- 6.0 mm diameter/13.0 mm overall length

Light Adjustable Lens Powers

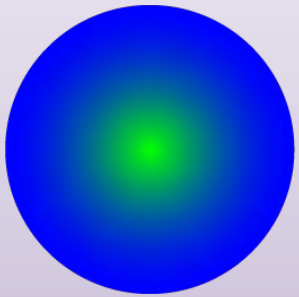
- -2.0 D to +15.0 D in 1.0 D increments
- +16.0 D to +24.0 D in 0.5 D increments
- +25.0 D to +30.0 D in 1.0 D increments

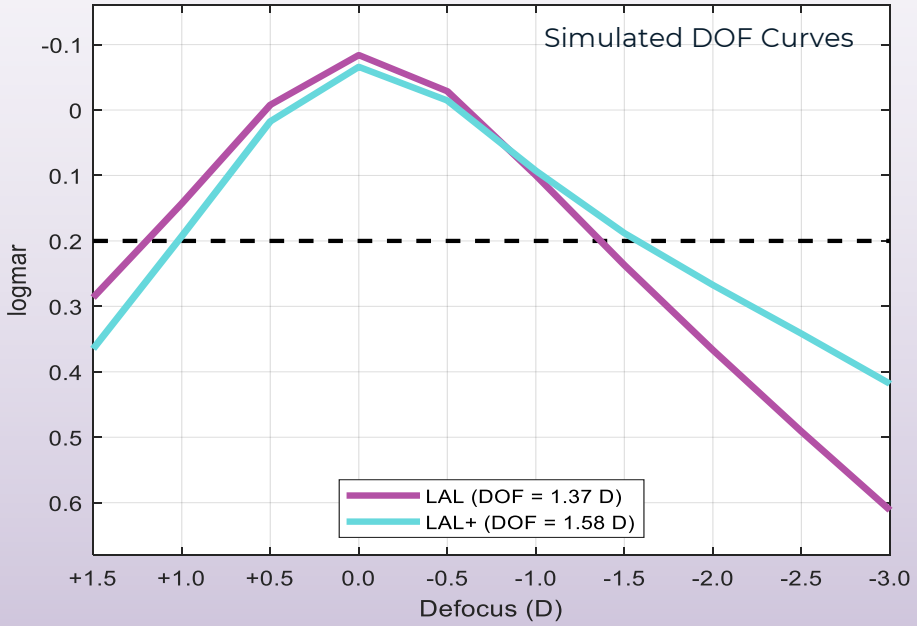
What is the LAL+?

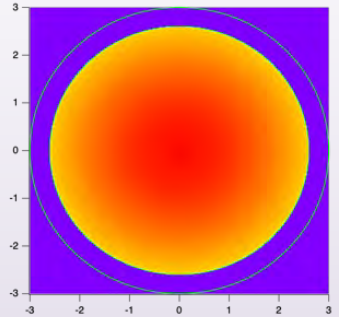
- The LAL+ has a slightly extended depth of focus by adding a small continuous increase in central lens power
- This optical design further extends the depth of focus prior to any light treatments, while maintaining high-quality distance vision.

LAL

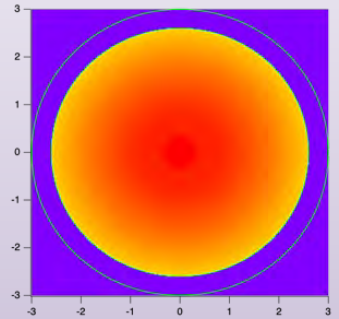
LAL+





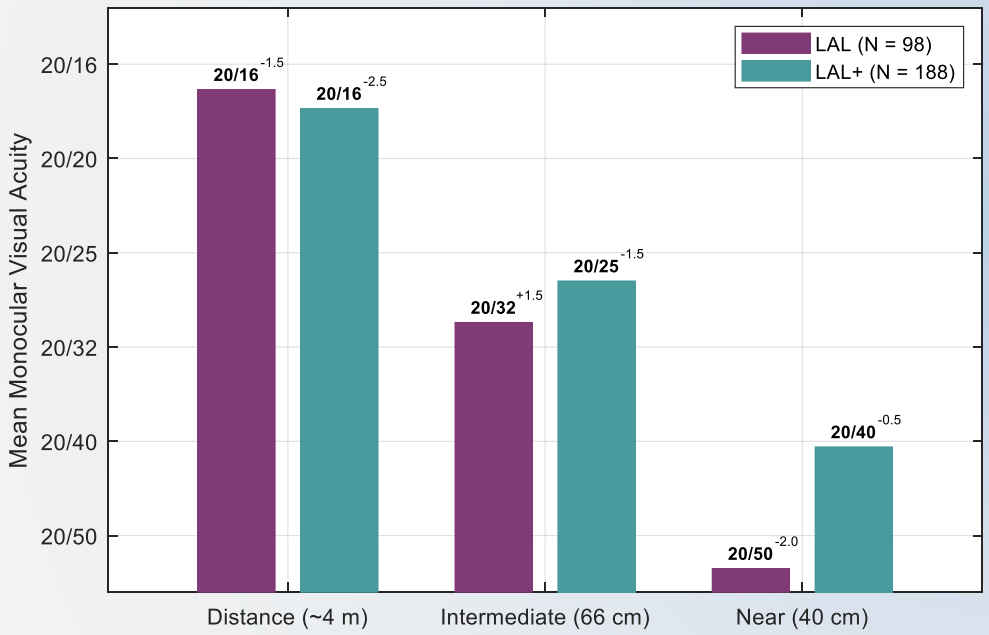


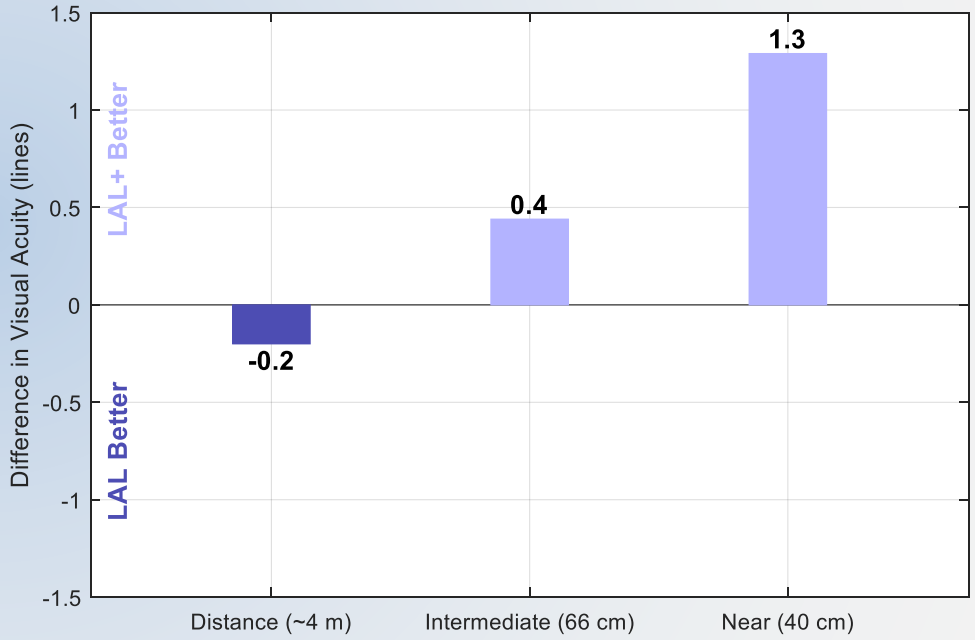
LAL



LAL+

Distance Corrected Visual Acuity LAL vs LAL+





1. RxSight PMCS-006 and PMCS-007 Clinical Outcomes of Patients Bilaterally Implanted with LAL and LAL+

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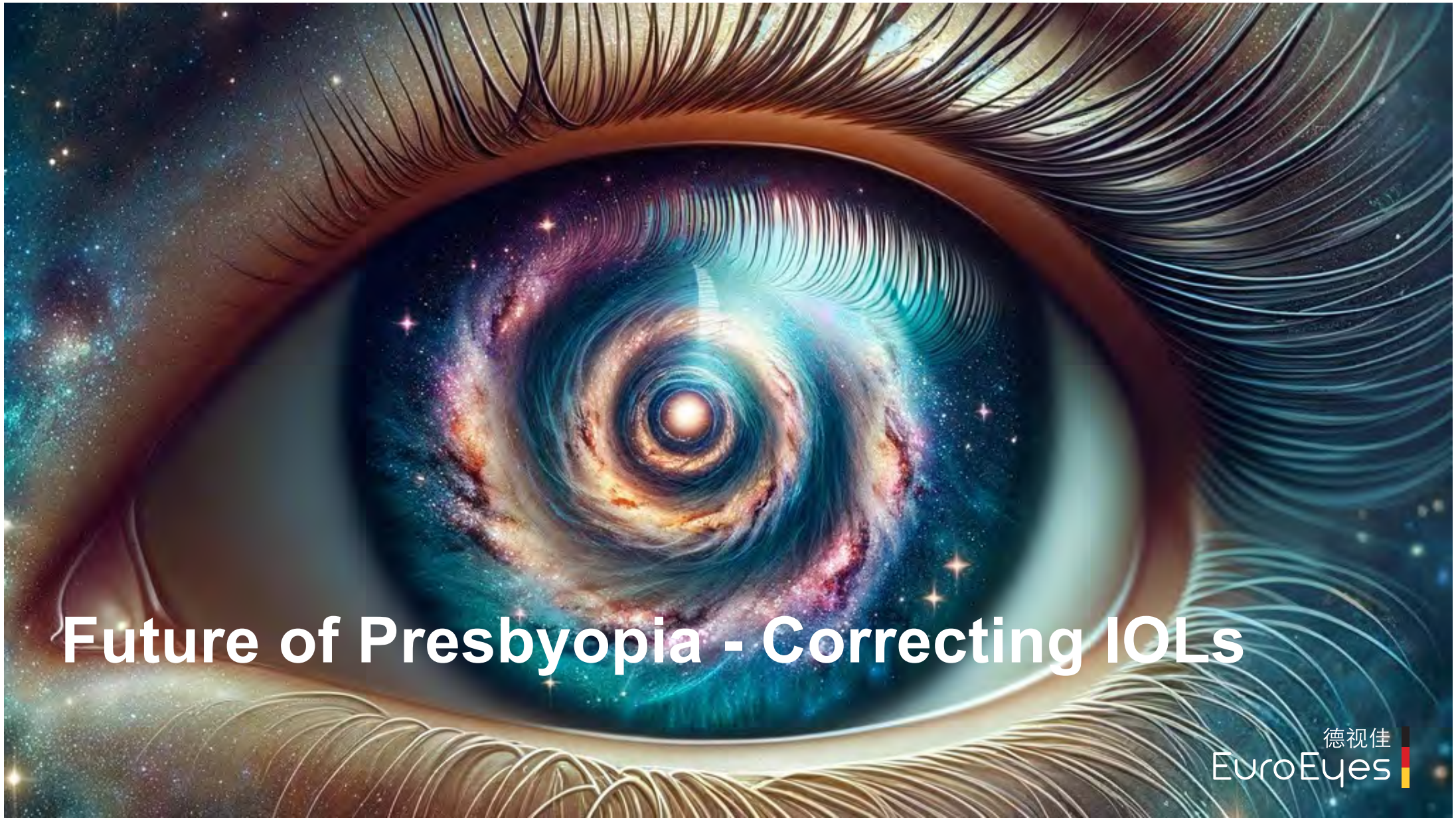
Future of Presbyopia - Correcting IOLs
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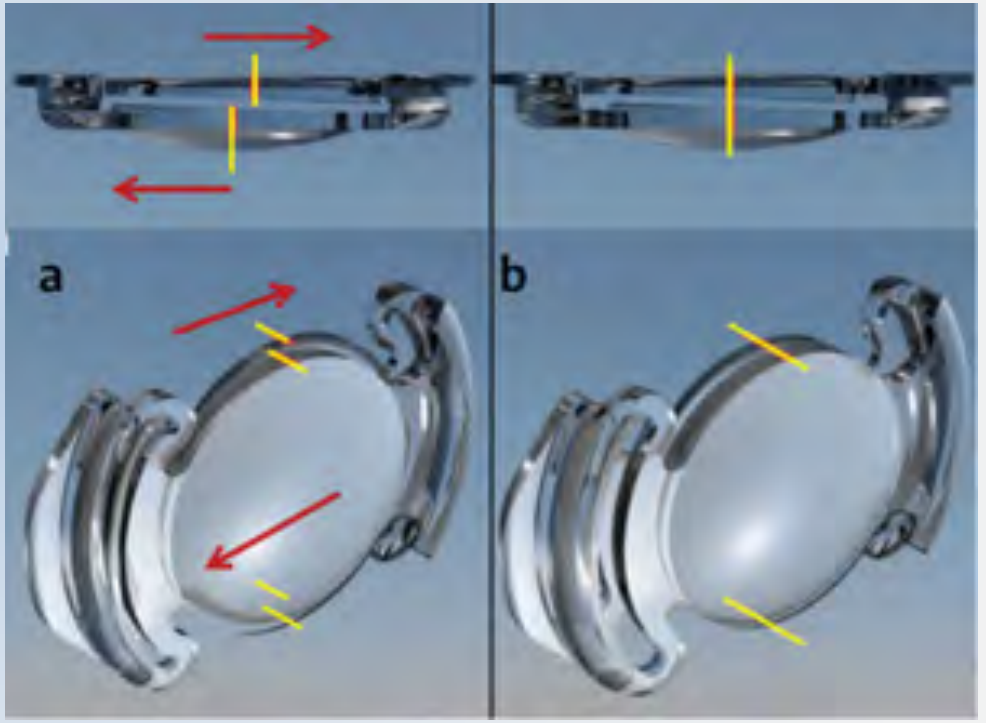
Lumina (AkkoLens International, The Netherlands)

- CE-marked 2024
- Sulcus placement
- Two lateral shifting optics



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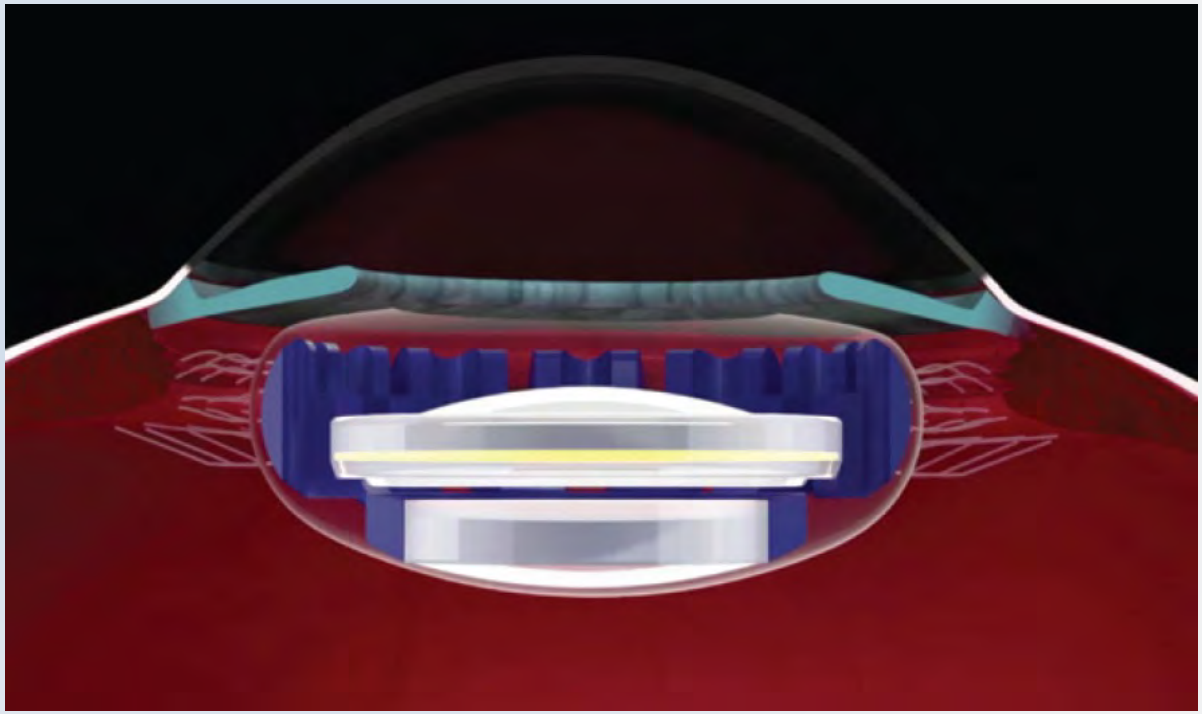
Juvene (LensGen, Irvine, CA)

- FDA trial completed
- Fluid-filled optic



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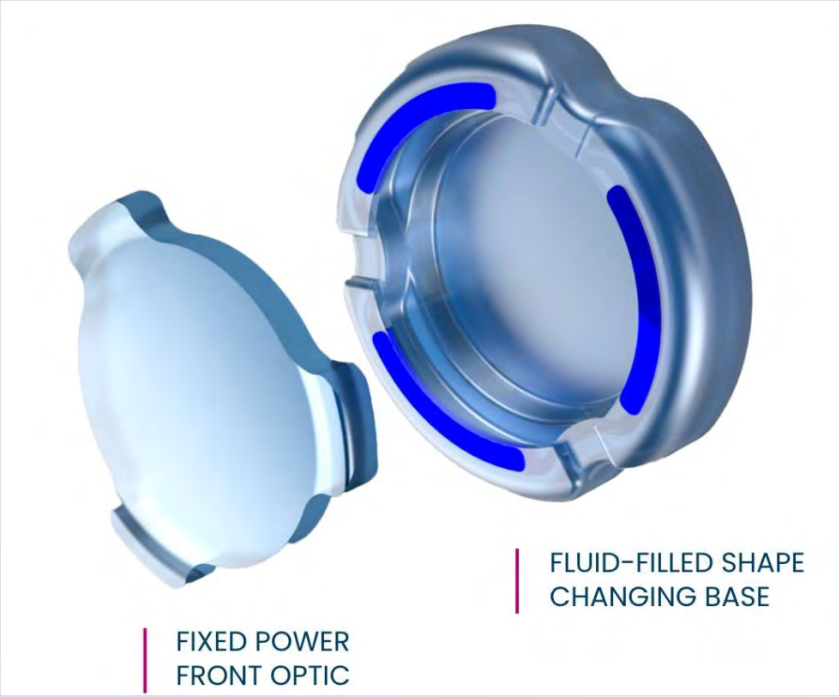
OmniVu (Atia Vision, Campbell, CA)

- IDE for FDA trial approved May 2025
- Dual optic
- Fluid-filled base



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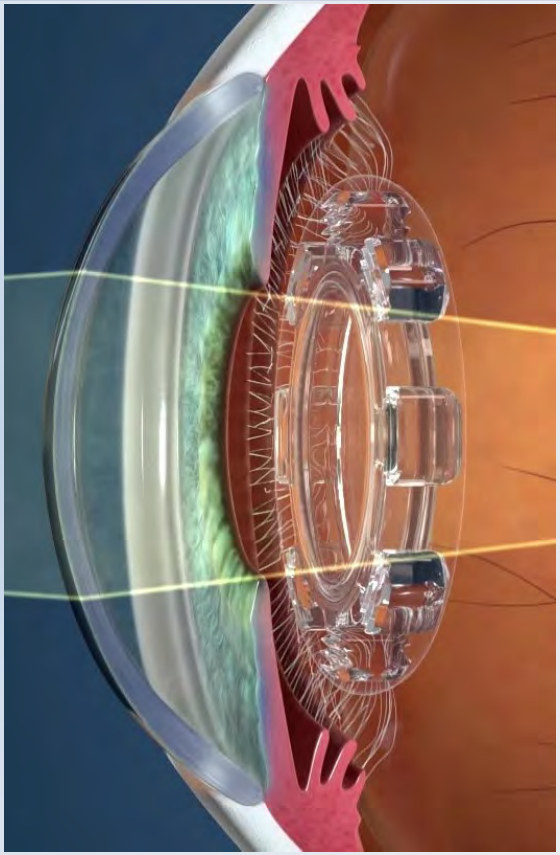
JelliSee IOL (JelliSee Ophthalmics, McLean, VA)

- Studies outside US
- Silicone oil filled optic



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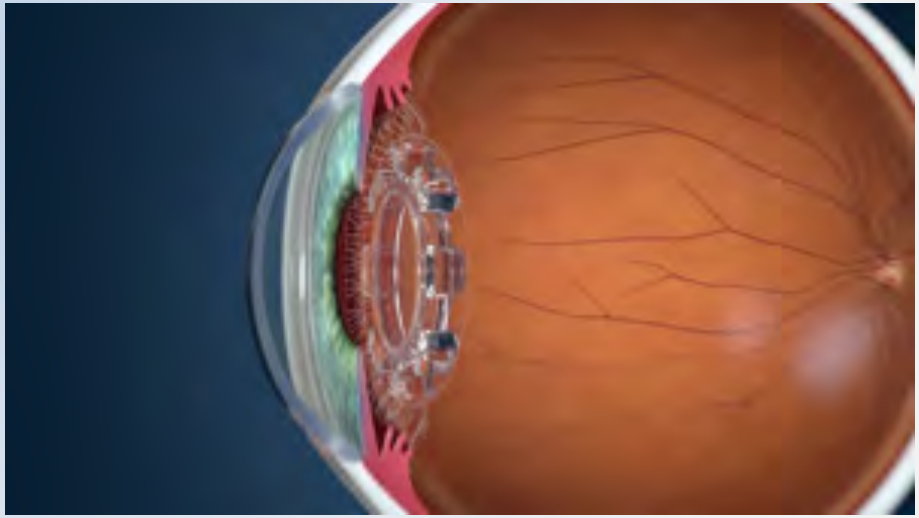
FluidVision IOL (Alcon, Ft. Worth, TX)

- Studies outside US
- Silicone oil filled optic



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Conclusions

Presbyopia – correcting IOLs will become standard of care

- Refractive EDoF IOLs will slowly replace monofocal IOLs
- *Adjustable EDoF IOLs (LAL+) are an exciting new option*
- Refractive MIOLs (Galaxy) will replace diffractive MIOL
- *Accommodating IOLs represent the next step into the future*

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Thank you !
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