Presbyopia Correction in the Absence of Cataract

Andrea Russo, MD, PhD, P-CEO, FWCRS

BOARD CERTIFIED FELLOW

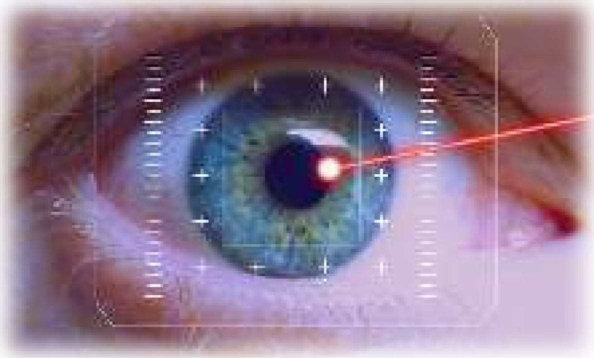
gruppo refrattivo italiano

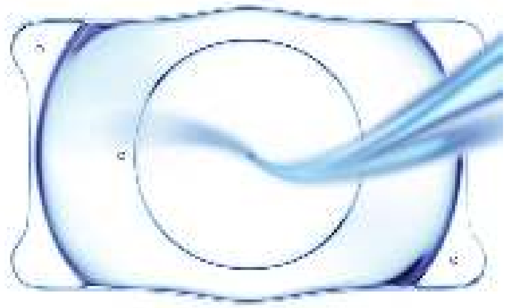
Presbyopia: The Challenge for Perfection

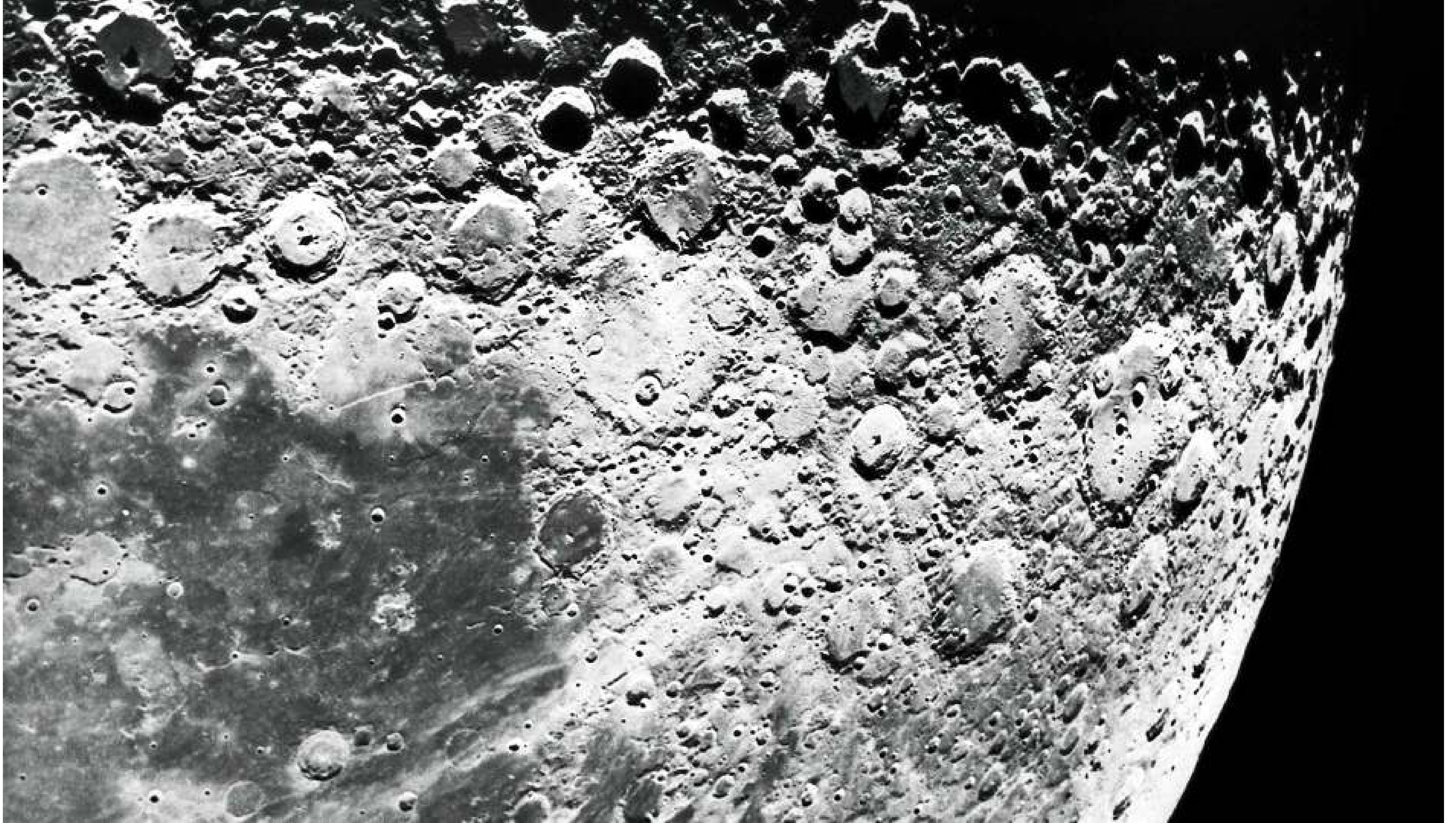
- Clear vision at **distance**
- Clear vision at **intermediate**
- Clear vision at **near**
- Maintaining **optical quality**
  - Safety
  - Contrast sensitivity
  - Night vision preservation
- Maintaining **binocularity**
- High patient **tolerance**
- Short **adaptation time**
- Simultaneous correction of **refractive error**
- **Reversibility**

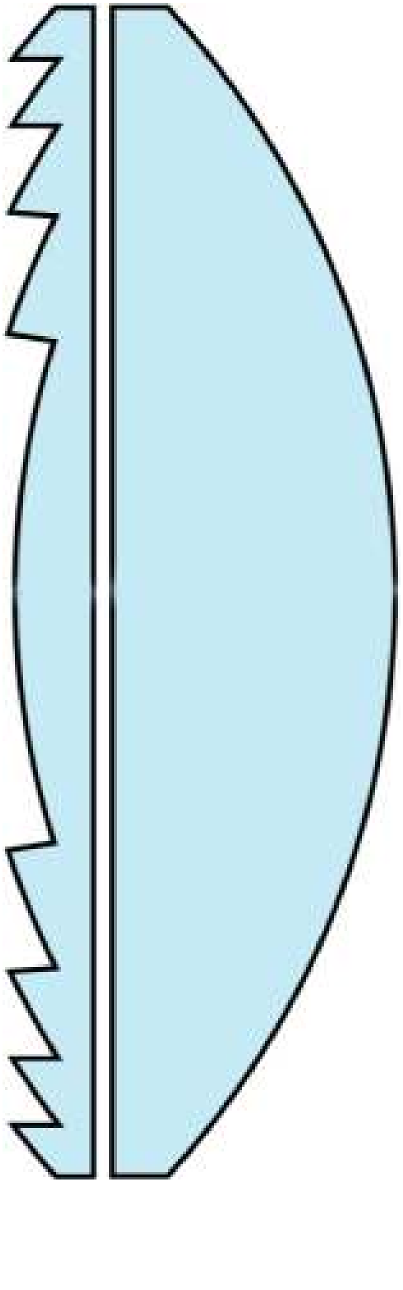
Trends in Presbyopic Correction

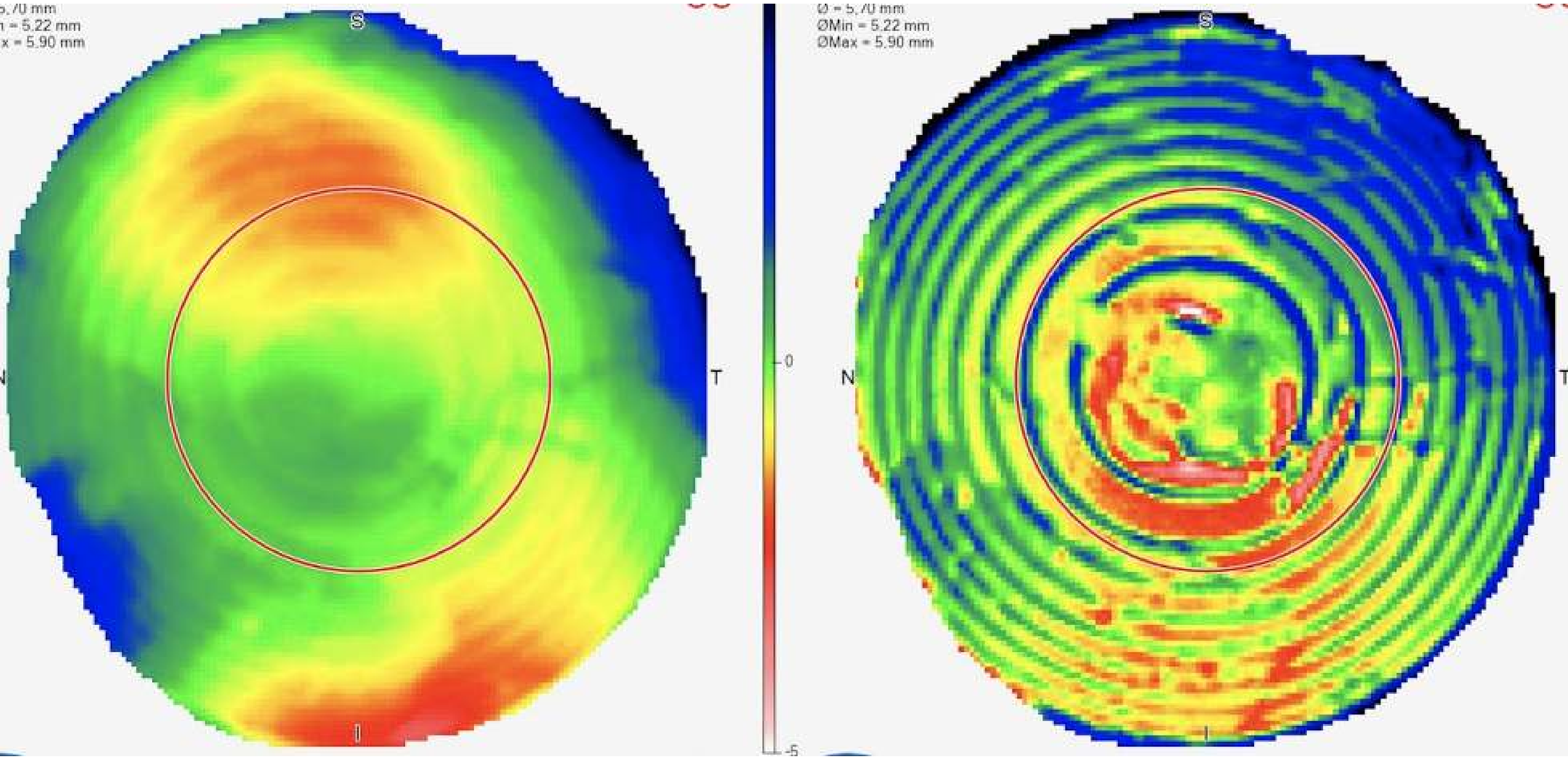
- **Monovision**
- **Multifocality**
- **EDoF**
    - **Pinhole Effect**
    - **Spherical Aberration**
- **EDoF + Anisometropia**





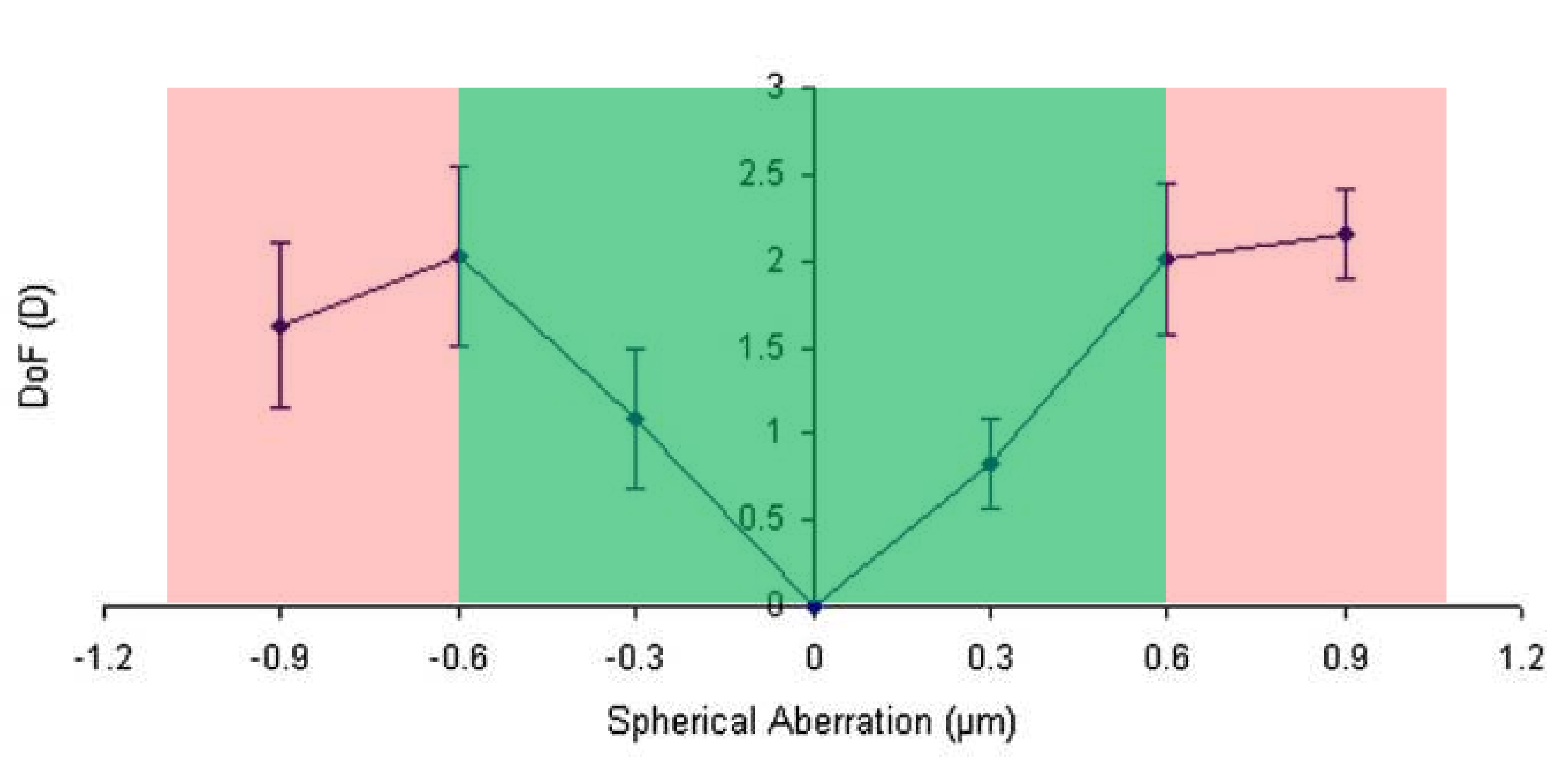






5,70 mm
n = 5.22 mm
x = 5.90 mm
S
N
T
I
0
-5
Ø = 5,70 mm
ØMin = 5.22 mm
ØMax = 5.90 mm
S
N
T
I

Expanding depth of focus by modifying higher-order aberrations induced by an adaptive optics visual simulator

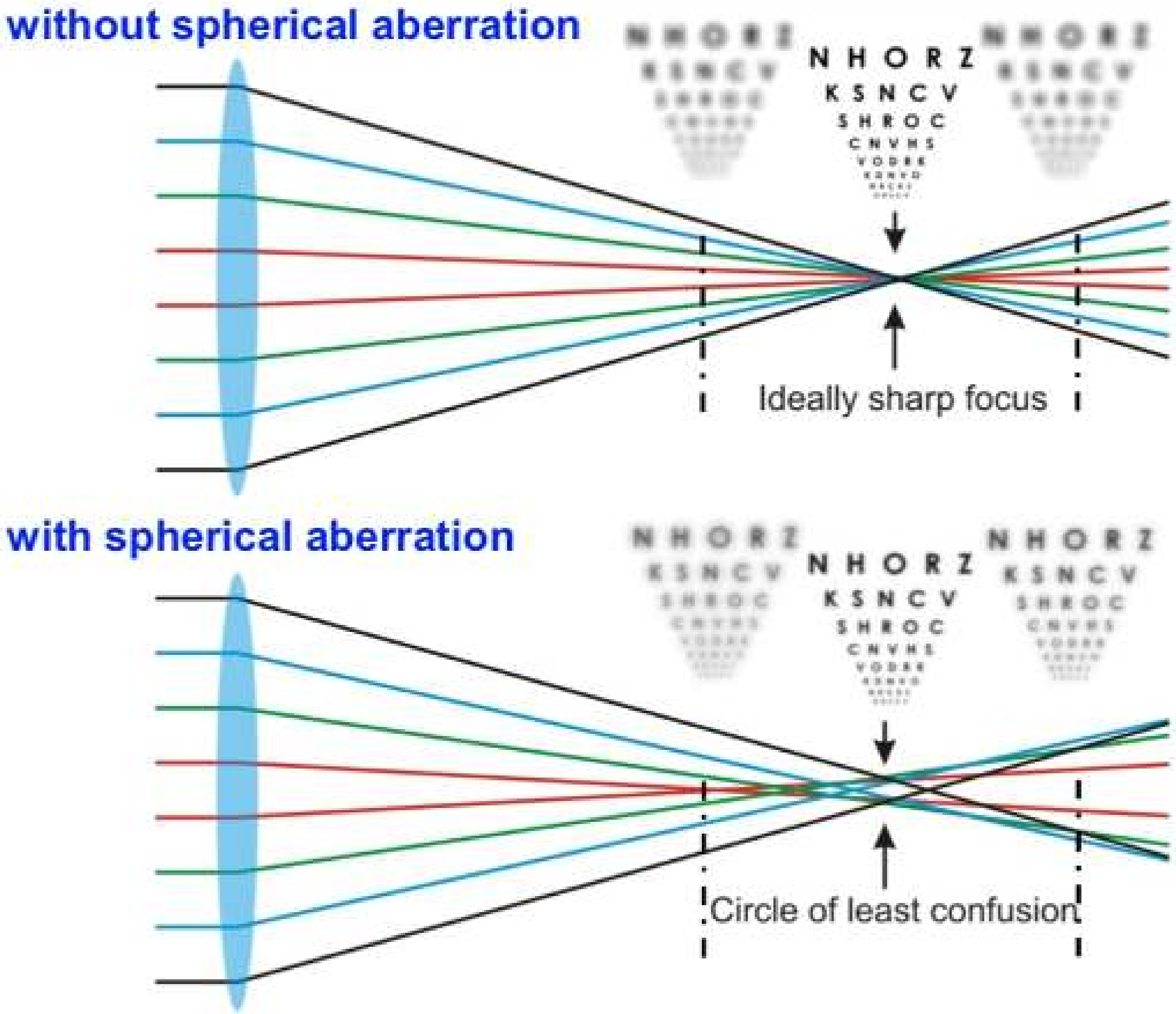


was increased to 0.9 µm. Trefoil and coma appeared to neither shift the center of focus nor significantly modify the depth of focus.

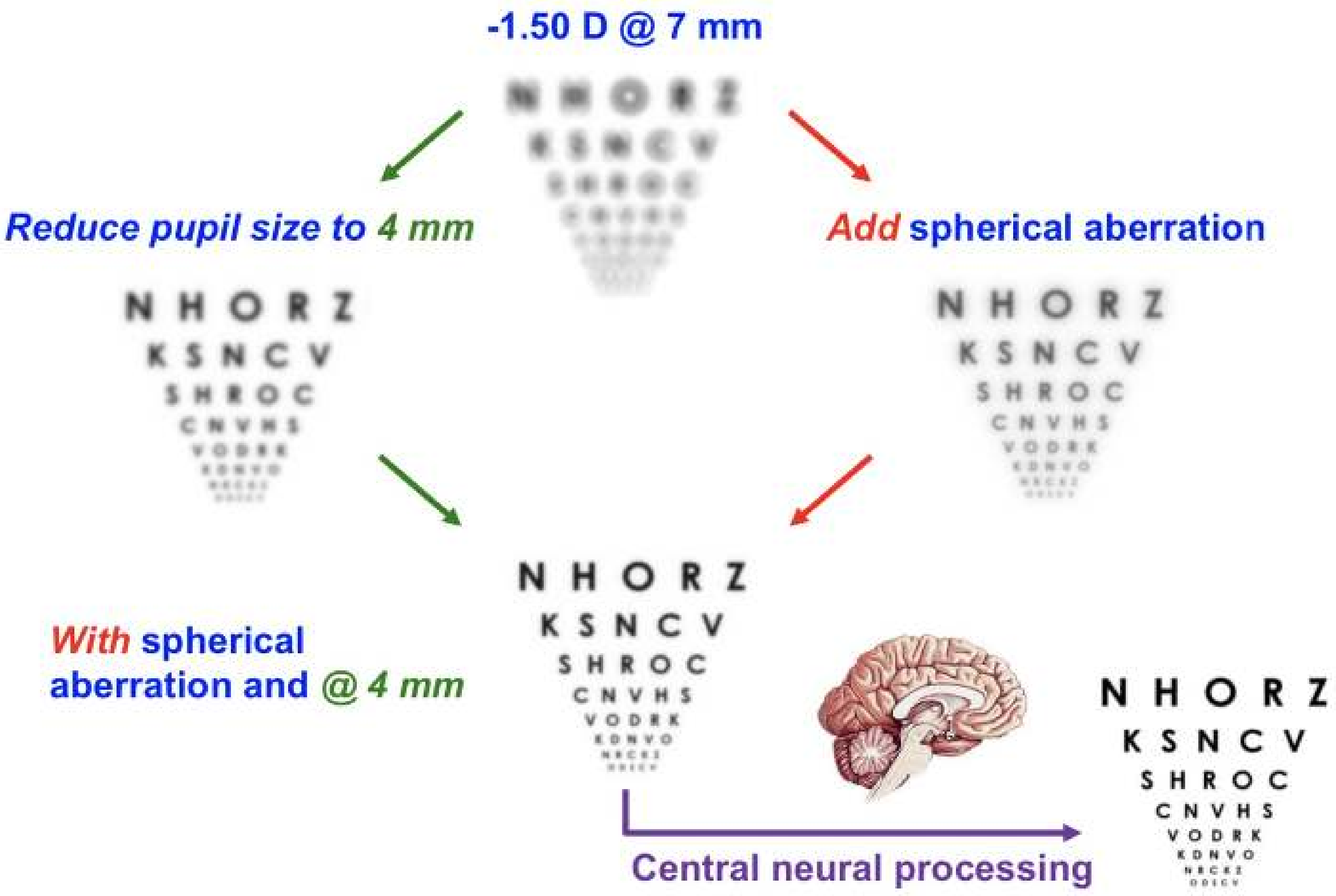
CONCLUSION: The introduction of both positive and negative spherical aberration using adaptive optics technology significantly shifted and expanded the subject's overall depth of focus; simulating coma or trefoil did not produce such effects.

J Cataract Refract Surg 2009; 35:1885–1892 © 2009 ASCRS and ESCRS

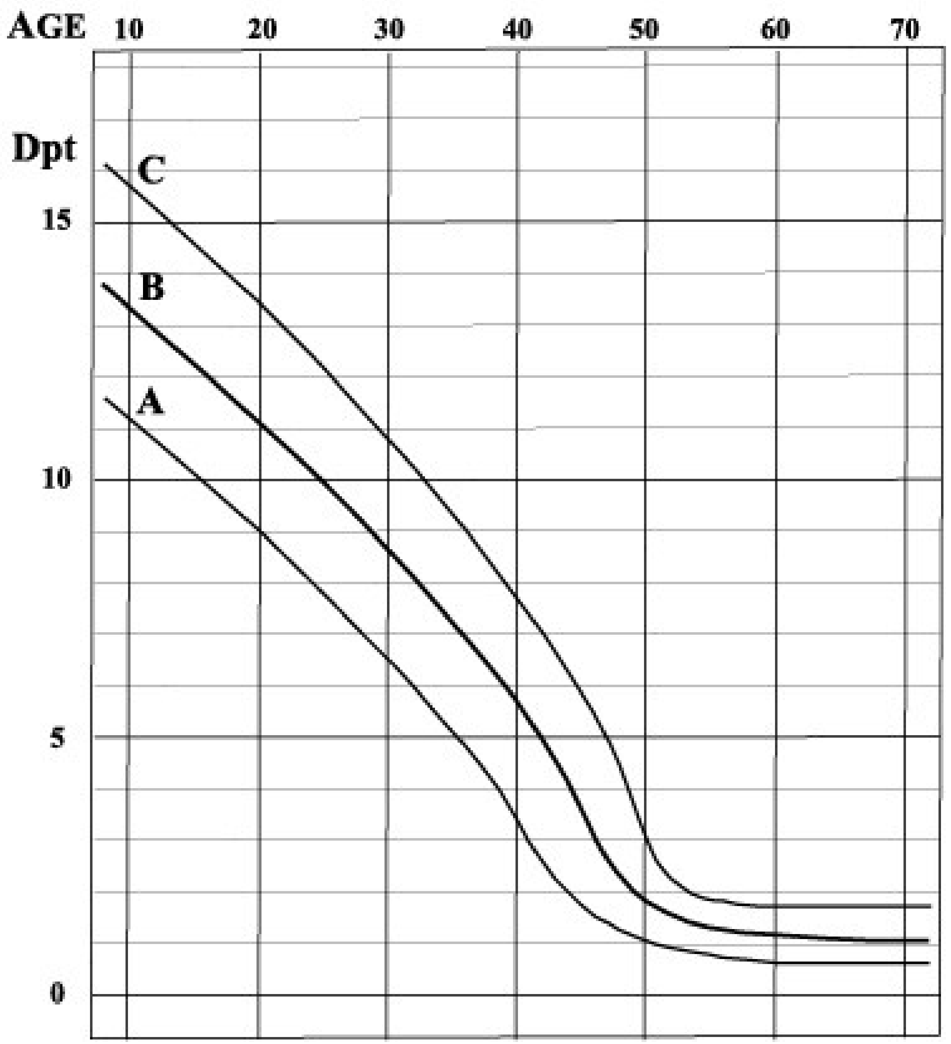
Influence of Spherical Aberration on Depth of Field



Simulation for -1.50 D defocus



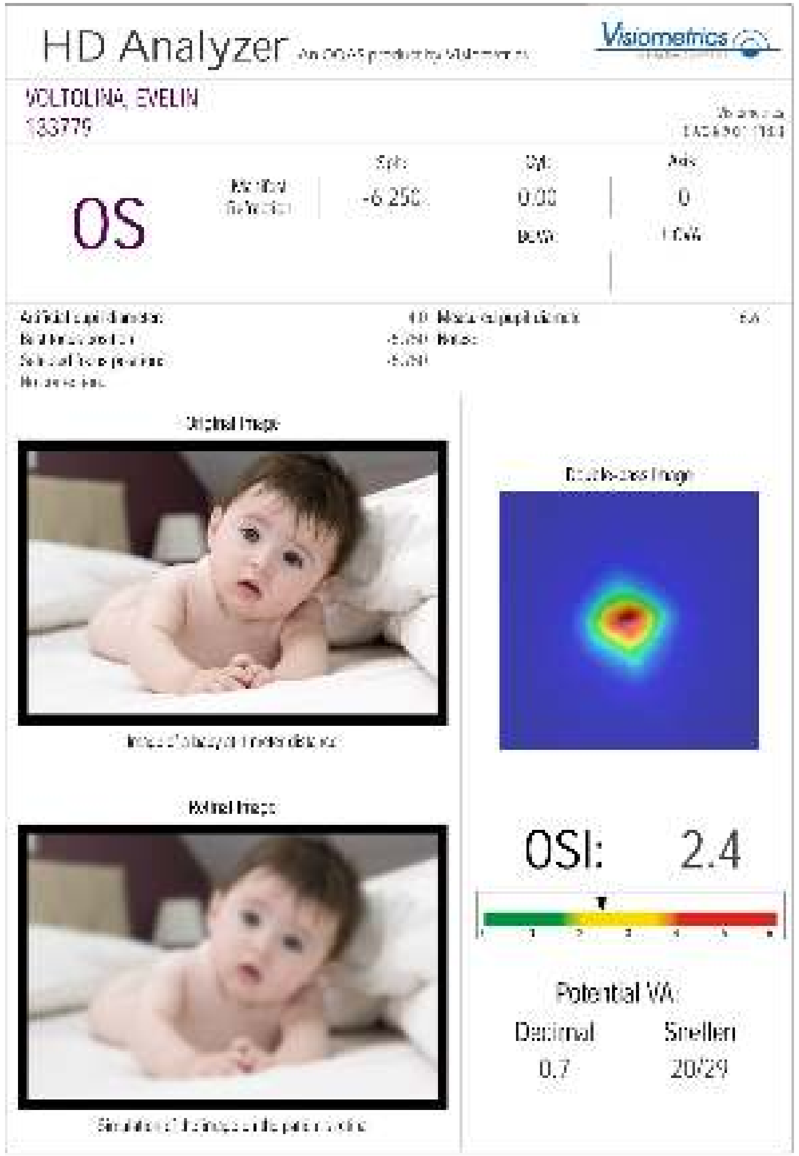
Accommodation Amplitude (Dpt) vs. Age



Duane, Alexander (1922). "Studies in Monocular and Binocular Accommodation with their Clinical Applications". *American Journal of Ophthalmology*. **5** (11): 865–877.

VS

Cataract vs Clear Lens Extraction



Challenges with Anisometropia

- Tolerance & Satisfaction
- Near/Distance Vision Loss
- Summation Loss
- Stereo Acuity Loss

BLENDED VISION

EDoF + Anisometropia

Tolerance & Satisfaction

Optical Phenomena and Visual Quality

The questionnaire was completed by 94 patients at 3 months postoperatively. Eighty-two patients (87.2%) would choose the same IOL again, whereas 12 (12.8%) would not choose the same IOL again if facing this decision with their experience after 3 months.

Factors influencing the subjective visual quality are listed in Table 5. The optical phenomena that had a direct influence on the overall satisfaction of the patients were mainly the scotopic, mesopic, and photopic phenomena, blurred vision, and overall visual quality (Table 6). In addition, patients with

Visual and patient-reported factors leading to satisfaction after implantation of diffractive extended depth-of-focus and trifocal intraocular lenses. Lwowski, Christoph t al. Journal of Cataract & Refractive Surgery: April 2022 - Volume 48 - Issue 4 - p 421-428

	Number of Patients		
Parameter	ReSTOR	ReZoom	P Value
Spectacle dependence			.29
Never	43	35	
Occasionally	7	15	
Always	0	0	
Glare			.48
None	21	17	
Mild	19	18	
Moderate	10	15	
Severe	0	0	
Halos			.10
None	23	14	
Mild	20	22	
Moderate	7	14	
Severe	0	0	
Satisfaction with uncorrected reading vision			.08
Very satisfied	25	14	
Satisfied	18	25	
Dissatisfied	7	11	
Satisfaction with intermediate vision			.04
Very satisfied	10	17	
Satisfied	29	30	
Dissatisfied	11	3	
Satisfaction with overall vision			.44
Very satisfied	36	27	
Satisfied	13	20	
Dissatisfied	1	3	

Functional vision with bilateral ReZoom and ReSTOR intraocular lenses 6 months after cataract surgery Chiam, Patrick J.T et al. Journal of Cataract & Refractive Surgery(12):2057-2061, December 2007.

Tolerance & Satisfaction

Degree of Disturbance	Number (%) Crystalens (n = 24 eyes)	Array (n = 32 eyes)	TwinSet (n = 24 eyes)
None	20 (83.4)	24 (75.1)	19 (79.2)
Slight	3 (12.5)	5 (15.6)	2 (8.3)
Moderate	1 (4.2)	2 (6.3)	1 (4.2)
Strong	0	1 (3.1)	2 (8.3)

Near vision restoration with refractive lens exchange and pseudoaccommodating and multifocal refractive and diffractive intraocular lenses: Comparative clinical study
J. Aliò et al. Journal of Cataract & Refractive Surgery30(12):2494-2503, December 2004.

Parameter	Number of Eyes (%) Multifocal (n = 53)	Monofocal (n = 67)	*P* Value
Trouble with vision*			.62
A little	20 (37.8)	25 (37.9)	
Moderate	8 (15.1)	4 (6.1)	
Great deal	0	1 (1.5)	
Satisfaction with vision*			.20
Very satisfied	26 (49.1)	37 (56.1)	
Satisfied	24 (45.3)	25 (37.9)	
Dissatisfied	3 (5.7)	4 (6.1)	
Very dissatisfied	0	0	
Glare*			.85
None	17 (32.7)	27 (40.3)	
Very little	17 (32.7)	20 (29.9)	
Moderate	11 (21.2)	13 (19.4)	
Severe	7 (13.5)	7 (10.5)	
Halos†			<.001
None	31 (59.6)	62 (92.5)	
Very little	15 (28.8)	3 (4.5)	
Moderate	3 (5.8)	2 (3.0)	
Severe	3 (5.8)	0	

*No significant difference between groups at 1 month
†Statistically significant difference in halos between groups at 1 month (P = .0007)

Quality of vision after AMO Array multifocal intraocular lens implantation. Sen, Nida H. MD et al. Journal of Cataract & Refractive Surgery30(12):2483-2493, December 2004

Tolerance & Satisfaction

TABLE D

Patient Satisfaction at the 6-Month Follow-up, and Dysphotopsia Score (Mean ± Standard Deviation)

Parameter	Myopia	Hyperopia
Distance vision (range)	95.8 ± 5.0 (85 to 100)	94.0 ± 5.9 (80 to 100)
Intermediate vision (range)	95.4 ± 4.4 (85 to 100)	94.4 ± 9.6 (85 to 100)
Near vision (range)	91.2 ± 7.7 (75 to 100)	95.5 ± 4.7 (85 to 100)
Spectacle independence (% of patients)		
Distance vision	100%, 39/39	98%, 98/100
Intermediate vision	95%, 37/39	96%, 96/100
Near vision	92%, 36/39	94%, 94/100
Dysphotopsia/glare score (% of patients)		
Grade 0 (Nil)	97%, 28/39	93%, 93/100
Grade 1 (Mild)	3%, 1/39	5%, 5/100
Grade 2 (Moderate)	0%, 0/39	2%, 2/100
Grade 3 (Severe)	0%, 0/39	0%, 0/90

Andrea Russo, Dan Z Reinstein, Ottavia Filini, Timothy J Archer, Giulia Festa et al. *Journal of Refractive Surgery*

TABLE 2

Postoperative Patient Satisfaction and Dysphotopsia Scores (Mean ± SD)[a,b]

Parameter	Myopia	Hyperopia
Distance vision	98.18 ± 2.10	97.43 ± 2.78
Intermediate vision	99.47 ± 0.62	99.22 ± 0.75
Near vision	95.84 ± 2.71	89.75 ± 4.14
Spectacle independence (% of patients)		
Distance vision	97% (37/38)	96% (60/63)
Intermediate vision	100% (38/38)	100% (63/63)
Near vision	95% (36/38)	89% (56/63)
Dysphotopsia score (% of patients)		
Grade 0 (Nil)	95% (36/38)	92% (58/63)
Grade 1 (Mild)	5% (2/38)	8% (5/63)
Grade 2 (Moderate)	0% (0/38)	0% (0/63)
Grade 3 (Severe)	0% (0/38)	0% (0/63)

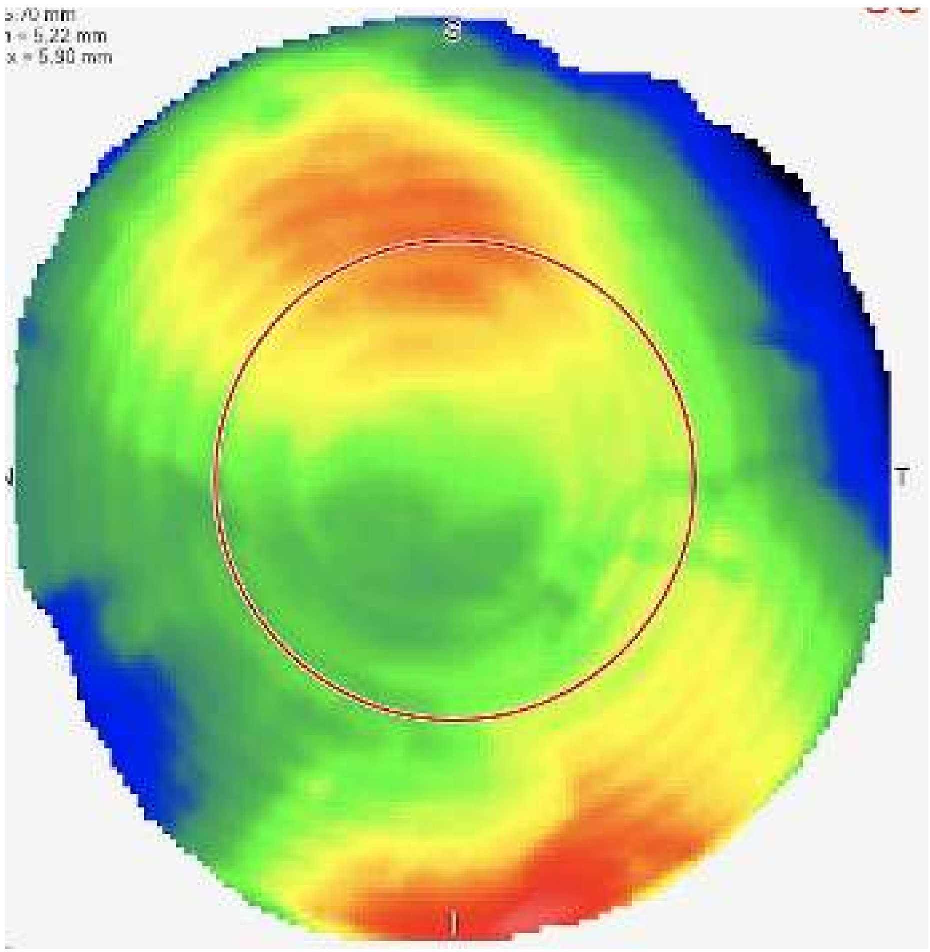
SD = standard deviation

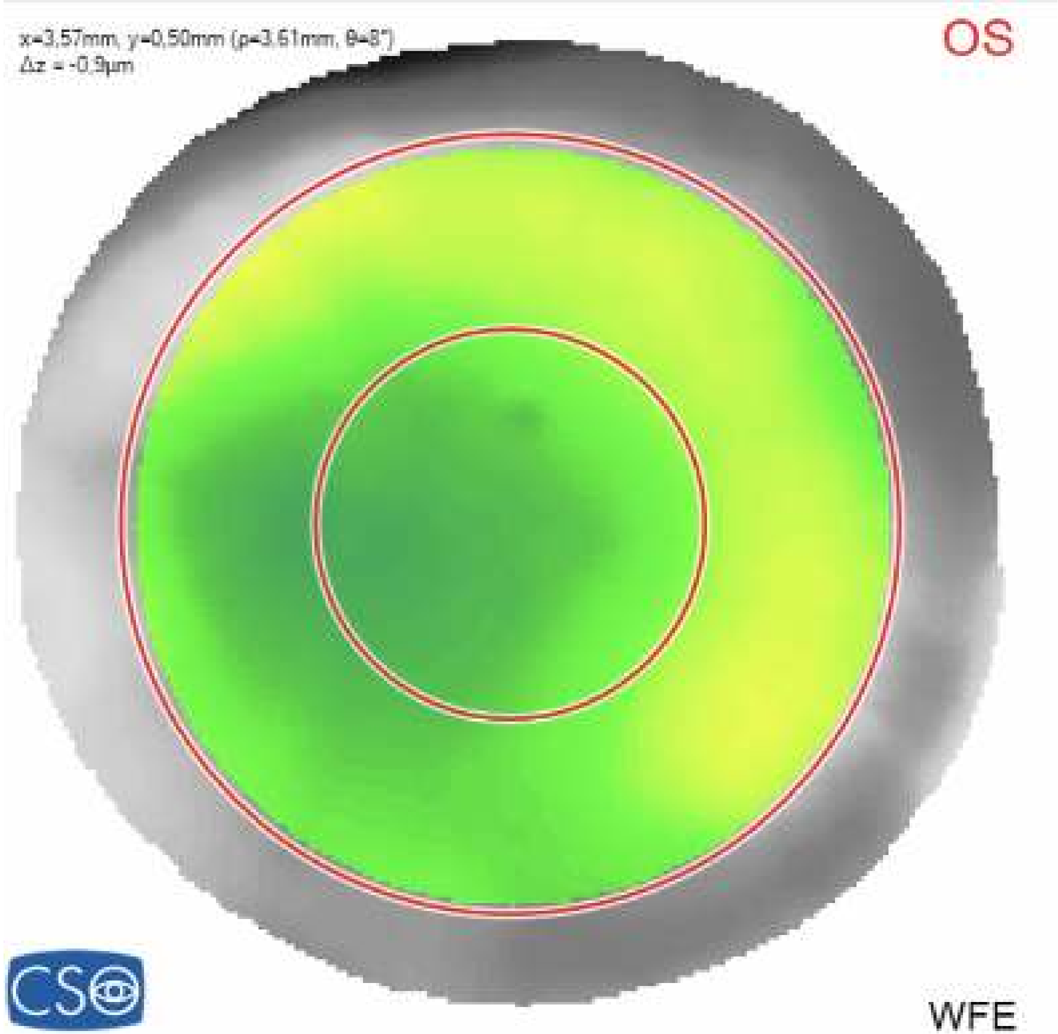
[a]Satisfaction questionnaire included scores ranging from 0 to 100, where 0 indicated not at all satisfied and 100 indicated completely satisfied, without the need of spectacles.

[b]Dysphotopsia grading was done as per the following questionnaire: 0 = nil, no dysphotopsia symptoms experienced; 1 = mild, minimal dysphotopsia not affecting night vision and routine activities; 2 = moderate, dysphotopsia symptoms affecting night vision and routine activities, but manageable; 3 = severe, bothersome dysphotopsia, severe enough to interfere in routine activities

Visual and Refractive Outcomes Following Laser Blended Vision Using Non-linear Aspheric Micro-monovision

Sri Ganesh, MS, DNB; Sheetal Brar, MS; Megha Gautam, MS; Karthik Sriprakash, MS Journal of Refractive Surgery


5,70 mm
5,22 mm
5,90 mm
S
N
T
I


x=3,57mm, y=0,50mm (ρ=3,61mm, θ=8°)
Δz = -0,9µm
OS
CSO
WFE

Near/Distance Vision Loss & Summation

TABLE C

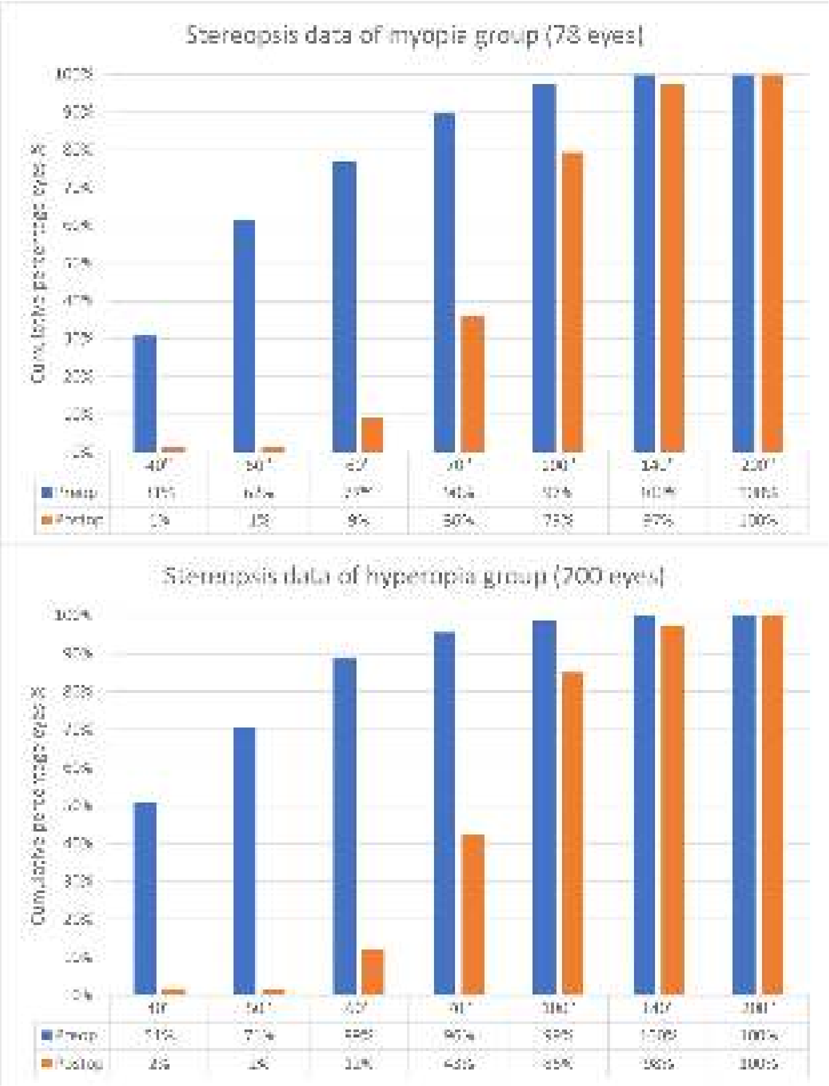
Visual Outcomes Data (logMAR, Snellen) for Distance Eyes, Near Eyes, and Binocularly for Myopia and Hyperopia Samples

Parameter	Myopia Distance Eyes	Myopia Near Eyes	Myopia Binocularly	Hyperopia Distance Eyes	Hyperopia Near Eyes	Hyperopia Binocularly
Preop CDVA, mean ± SD (range)	-0.03 ± 0.06 (0.00 to -0.20)	-0.03 ± 0.06 (0.00 to -0.20)	-0.04 ± 0.05 (0.00 to -0.20)	-0.02 ± 0.06 (-0.20 to 0.10)	-0.02 ± 0.06 (-0.20 to 0.10)	-0.04 ± 0.05 (-0.20 to 0.10)
Postop CDVA, mean ± SD (range)	-0.07 ± 0.07 (0.00 to -0.20)	-0.04 ± 0.06 (0.00 to -0.20	-0.08 ± 0.05 (0.00 to -0.20)	-0.03 ± 0.06 (-0.20 to 0.10)	-0.02 ± 0.07 (-0.20 to 0.10)	-0.04 ± 0.06 (-0.20 to 0.10)
Postop UDVA, mean ± SD (range)	-0.01 ± 0.03 (0.00 to -0.10)	0.11 ± 0.17 (-0.10 to 0.50)	-0.08 ± 0.09 (-0.10 to 0.20)	0.01 ± 0.06 (-0.10 to 0.40)	0.28 ± 0.20 (0.00 to 0.80)	-0.06 ± 0.12 (-0.10 to 0.40)
Postop UNVA, mean ± SD (range)	0.46 ± 0.22 (0.10 to 0.80)	0.18 ± 0.14 (0.00 to 0.50)	0.15 ± 0.16 (0.00 to 0.50)	0.45 ± 0.18 (0.00 to 0.70)	0.16 ± 0.14 (0.00 to 0.60)	0.10 ± 0.15 (0.00 to 0.60)

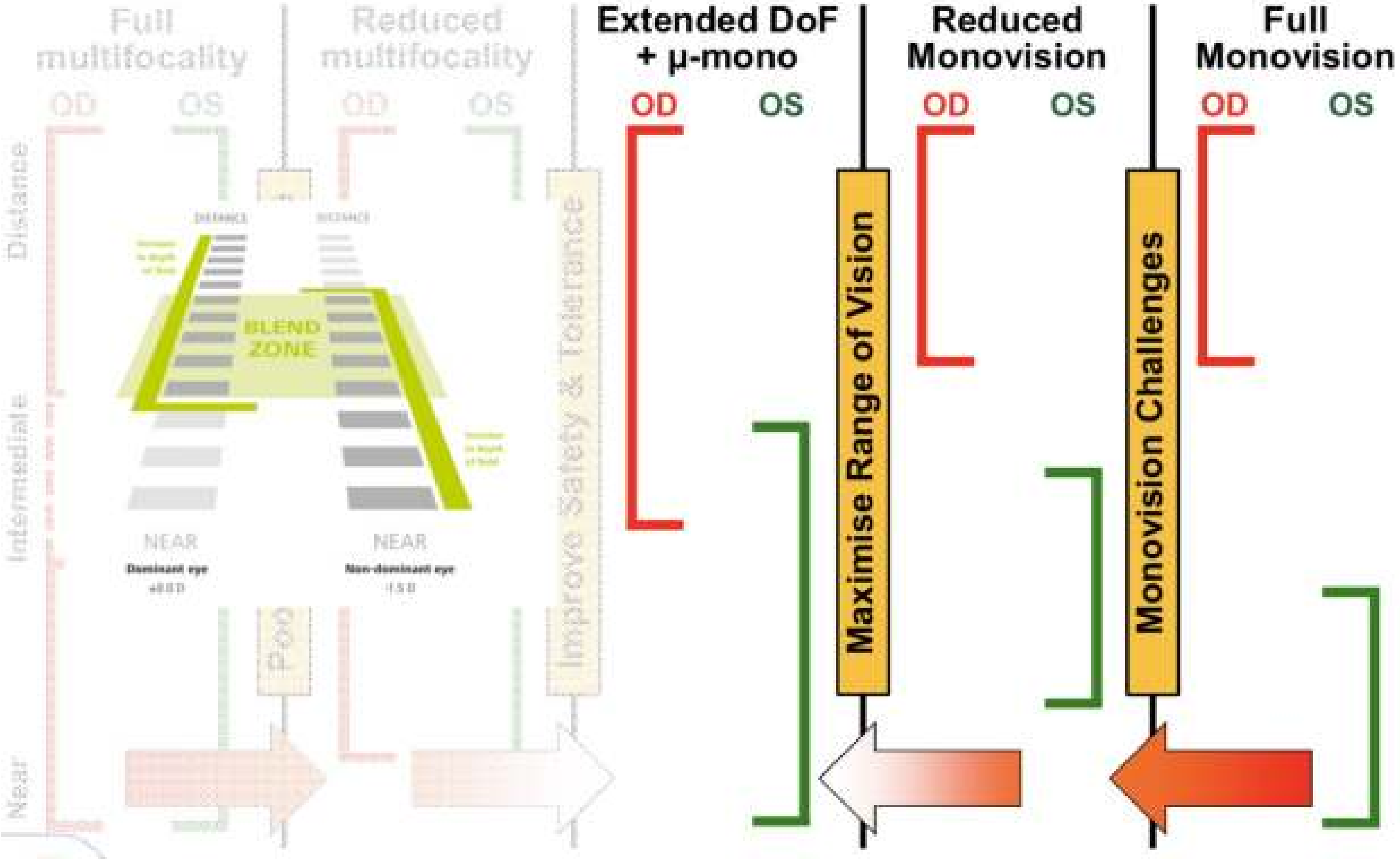
CDVA = corrected distance visual acuity; SD = standard deviation; UDVA = uncorrected distance visual acuity; UNVA = uncorrected near visual acuity

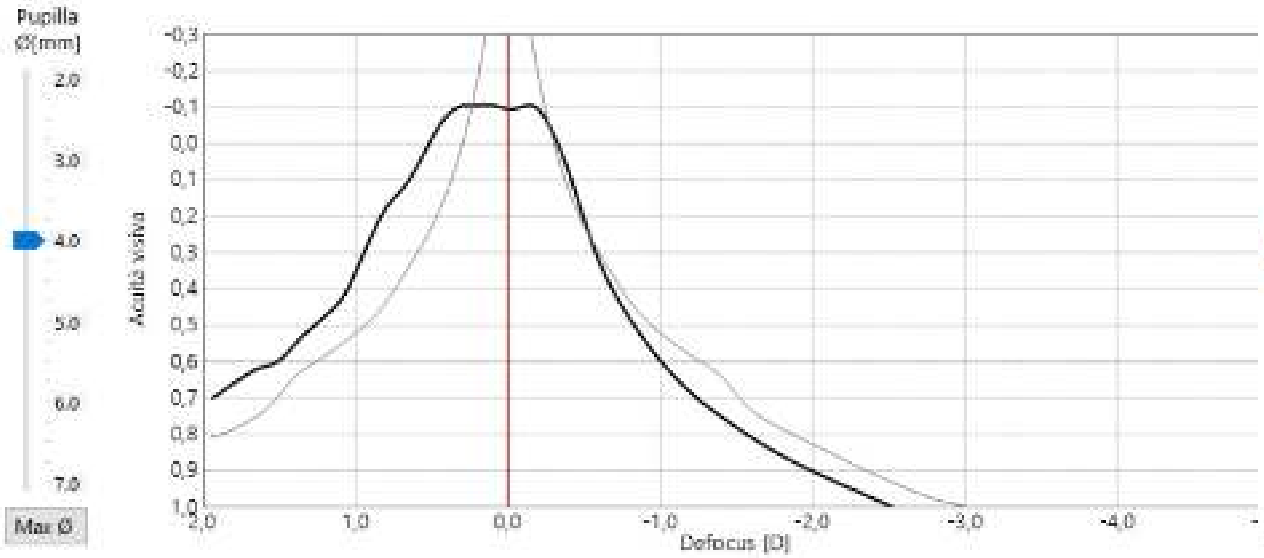
Andrea Russo, Dan Z Reinstein, Ottavia Filini, Timothy J Archer, Giulia Festa et al. *Journal of Refractive Surgery*

Stereo Acuity

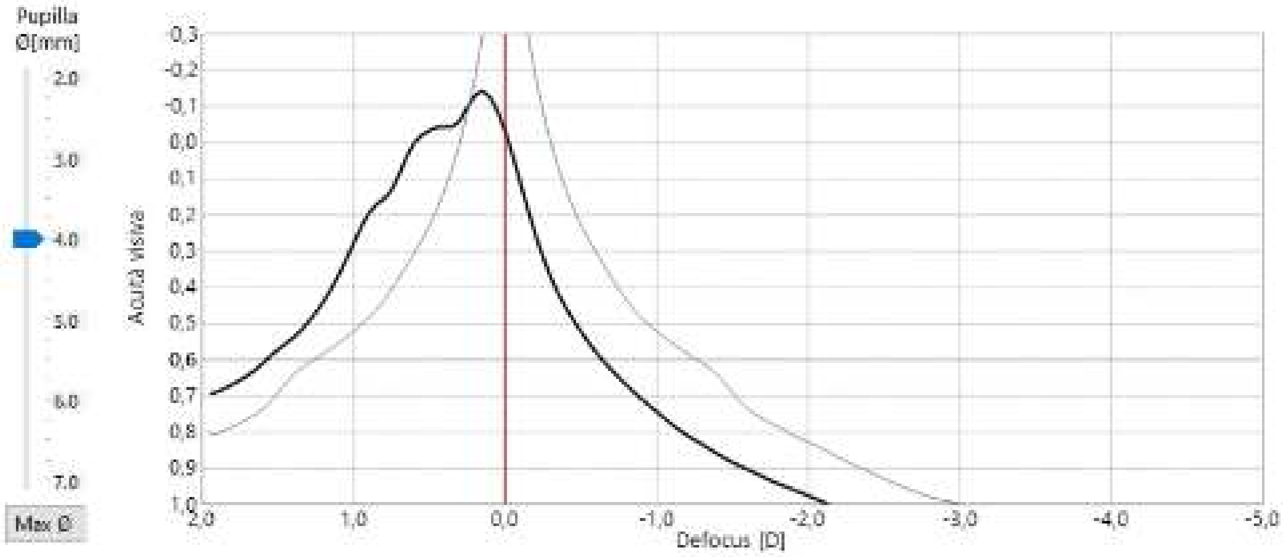


Andrea Russo, Dan Z Reinstein, Ottavia Filini, Timothy J Archer, Giulia Festa et al. *Journal of Refractive Surgery*

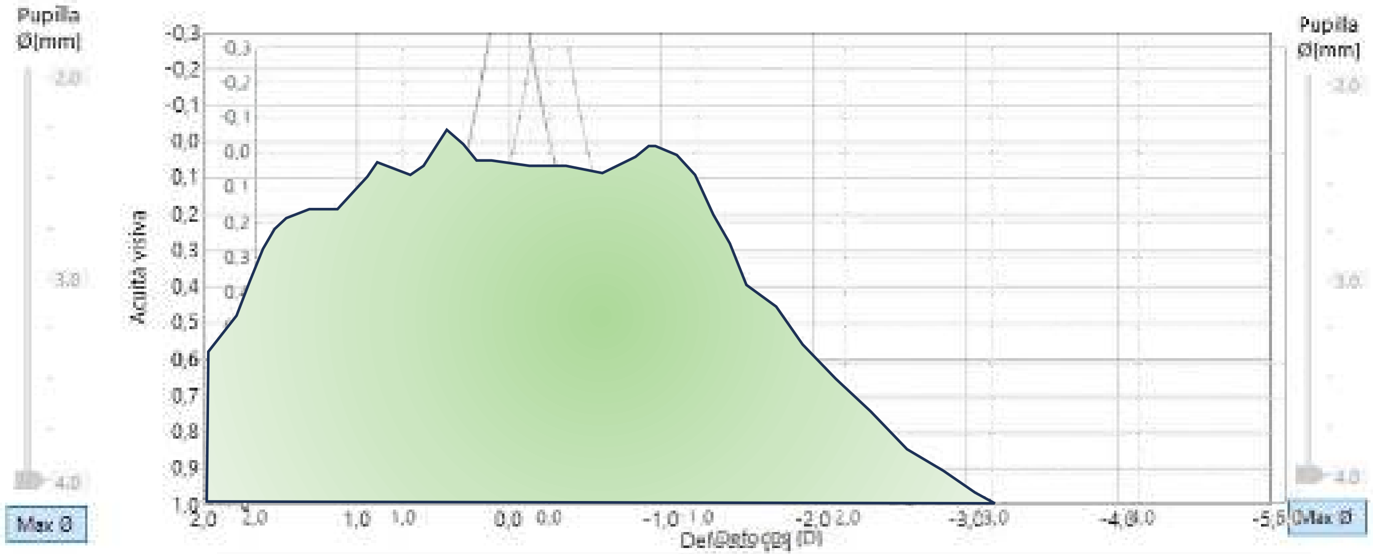

Full multifocality
OD
OS
Reduced multifocality
OD
OS
Distance
Intermediate
Near
DISTANCE
DISTANCE
BLEND ZONE
NEAR
NEAR
Dominant eye
Non-dominant eye
Improve Safety & Tolerance
Extended DoF + μ-mono
OD
OS
Maximise Range of Vision
Reduced Monovision
OD
OS
Monovision Challenges
Full Monovision
OD
OS



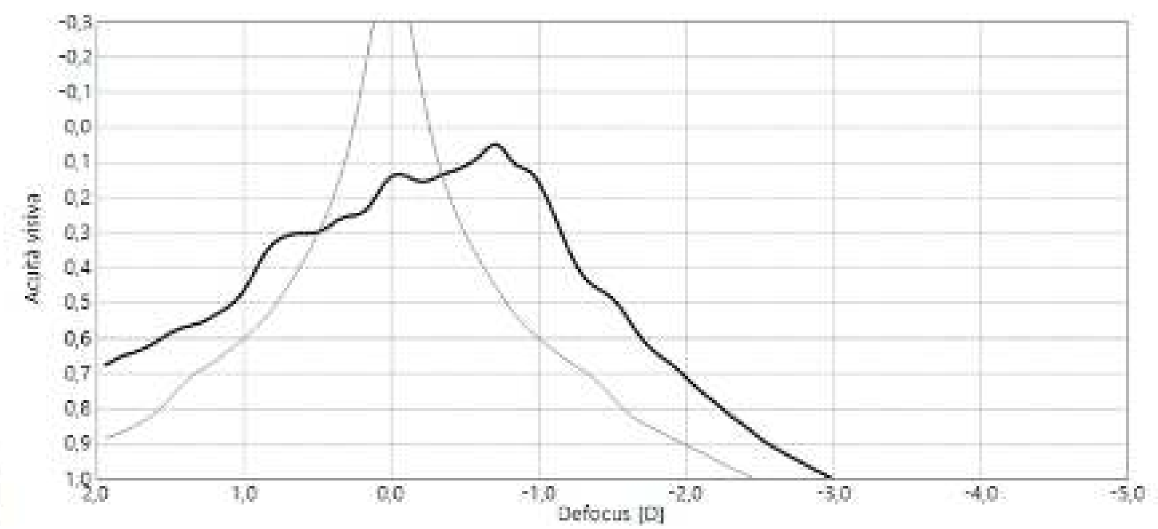
Pupilla
Ø[mm]
2.0
3.0
4.0
5.0
6.0
7.0
Max Ø
Acuità visiva
Defocus [D]



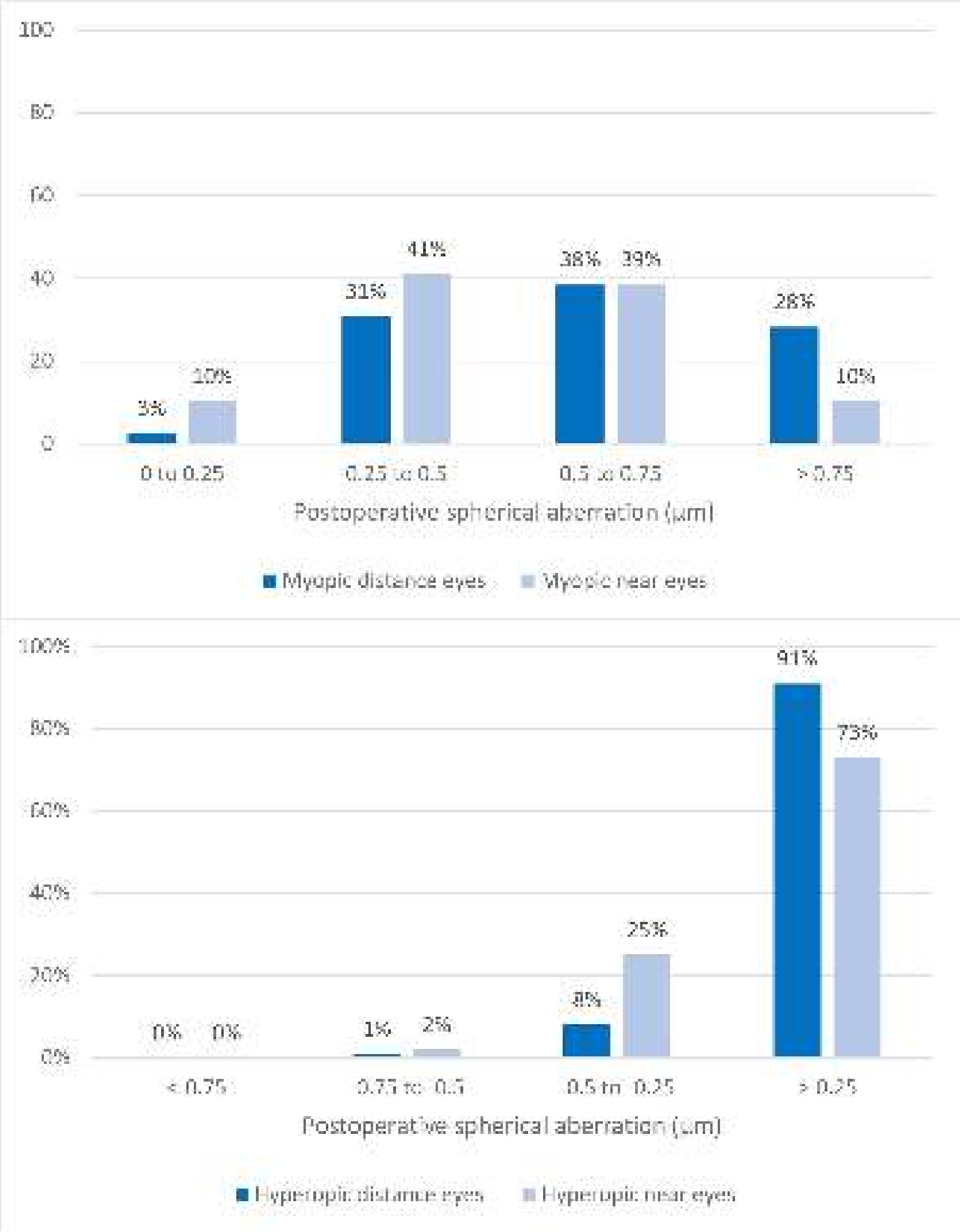
Pupilla
Ø[mm]
2.0
3.0
4.0
5.0
6.0
7.0
Max Ø
Acuità visiva
Defocus [D]



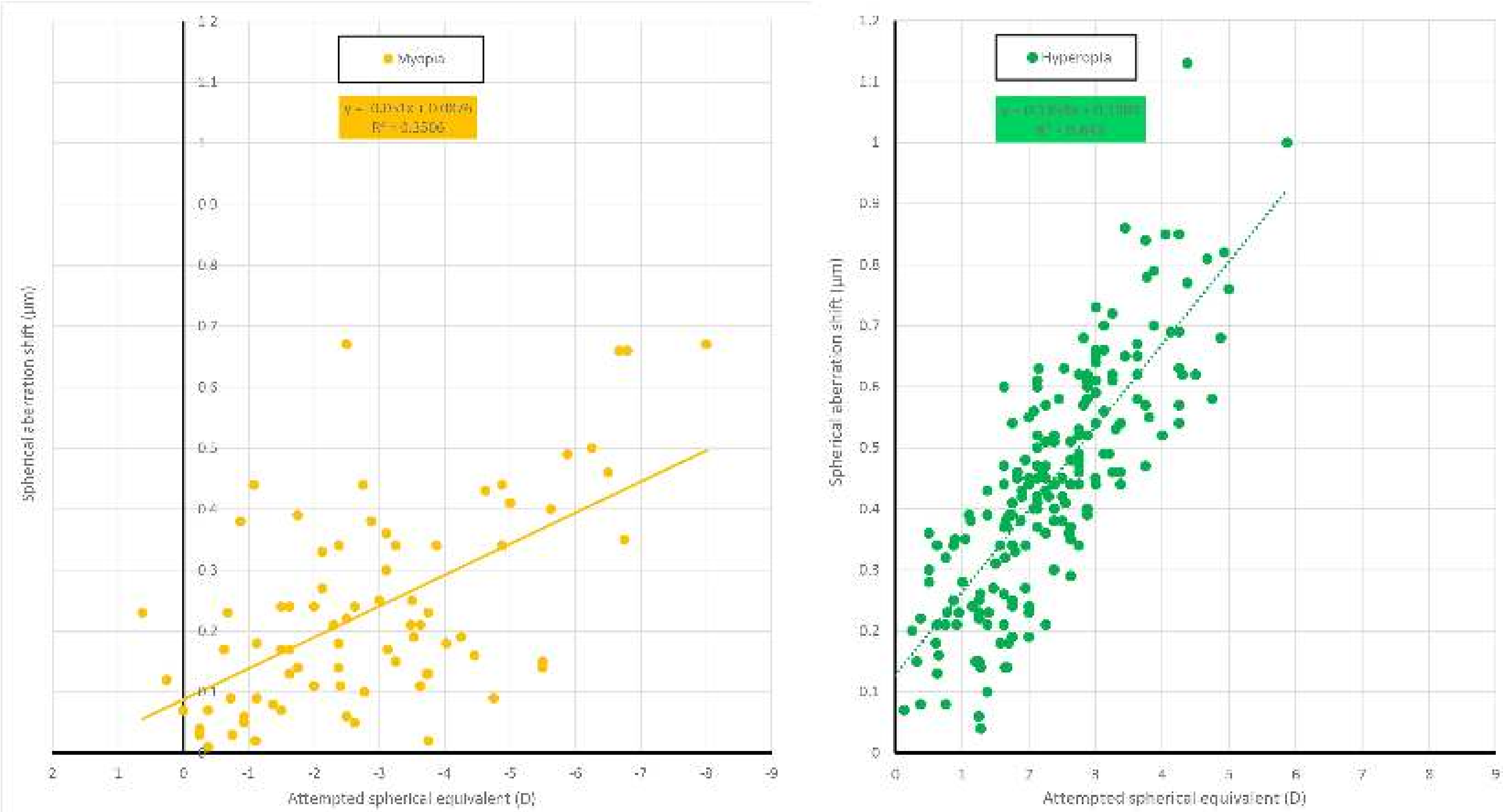
Pupilla
Ø[mm]
Max Ø
Acuità visiva



Acuità visiva
Defocus [D]



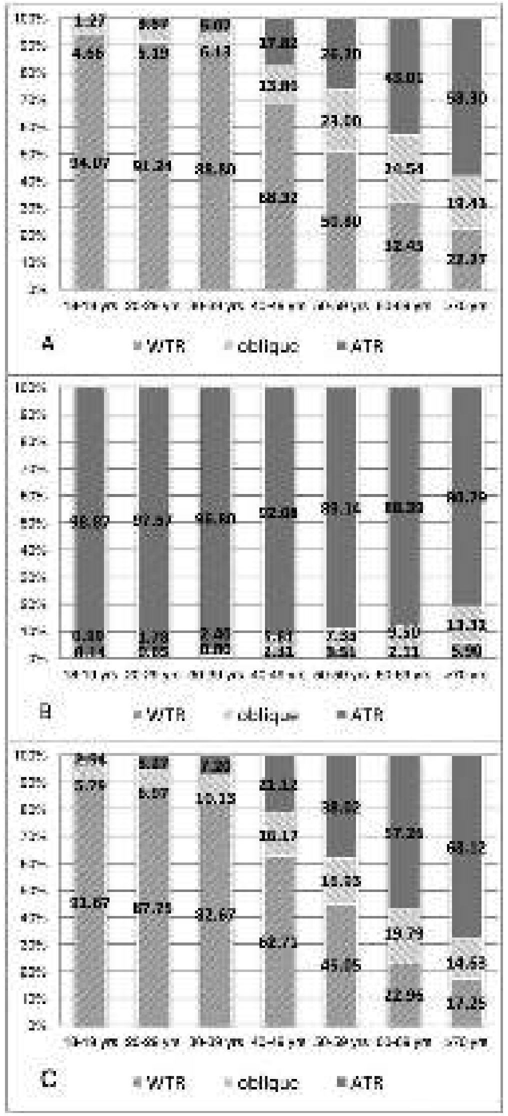
Andrea Russo, Dan Z Reinstein, Ottavia Filini, Timothy J Archer, Giulia Festa et al. *Journal of Refractive Surgery*

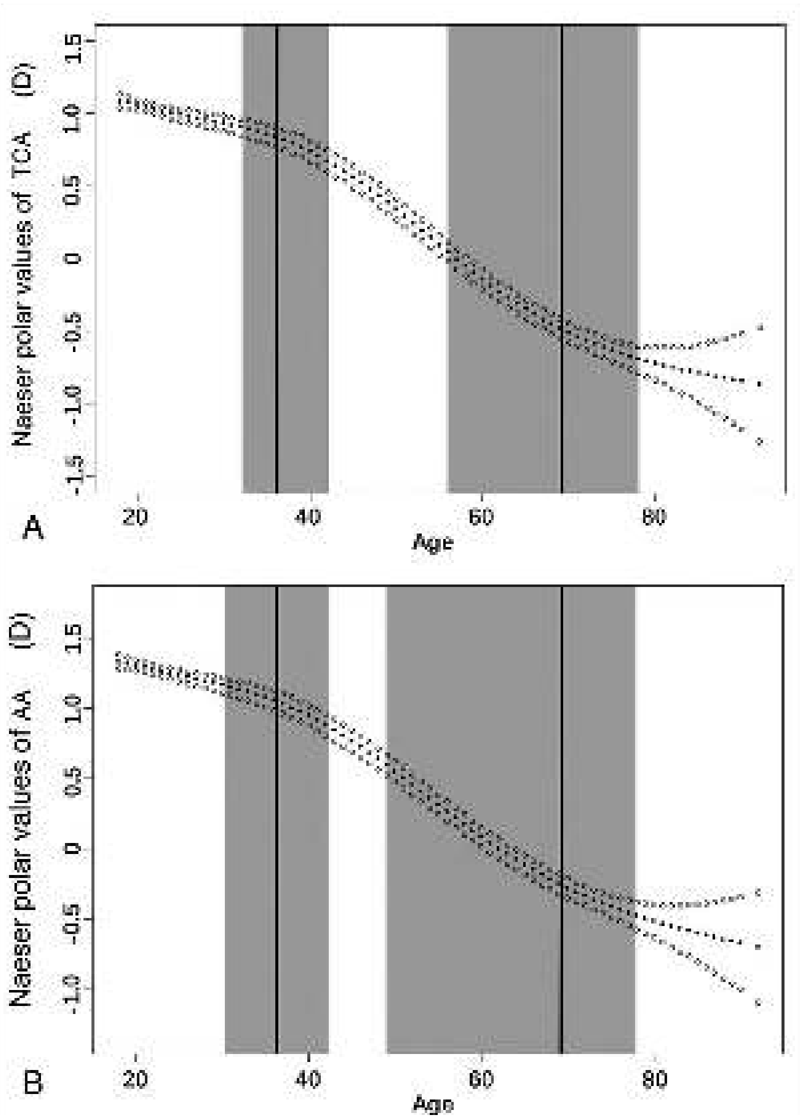


Myopia
Spherical aberration shift (µm)
Attempted spherical equivalent (D)
Hyperopia
Spherical aberration shift (µm)
Attempted spherical equivalent (D)

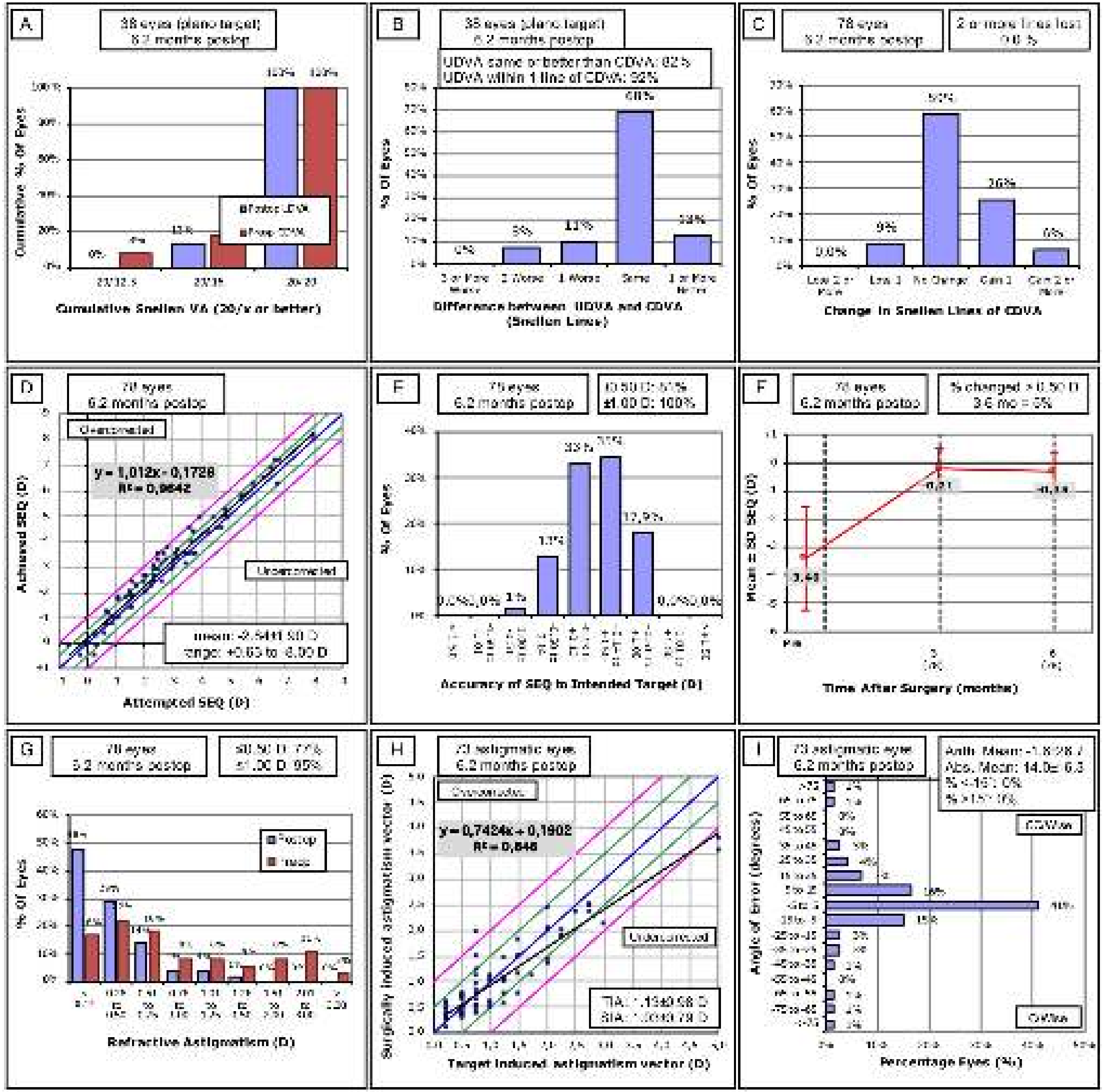
Astigmatism and Aging

*The average change of total corneal astigmatism toward against-the-rule astigmatism was 0.13 diopters (D)/10 years from 18 to 35 years, **0.45 D/10 years from 36 to 68 years**, and decreased after 69 years, mainly caused by anterior corneal astigmatism*

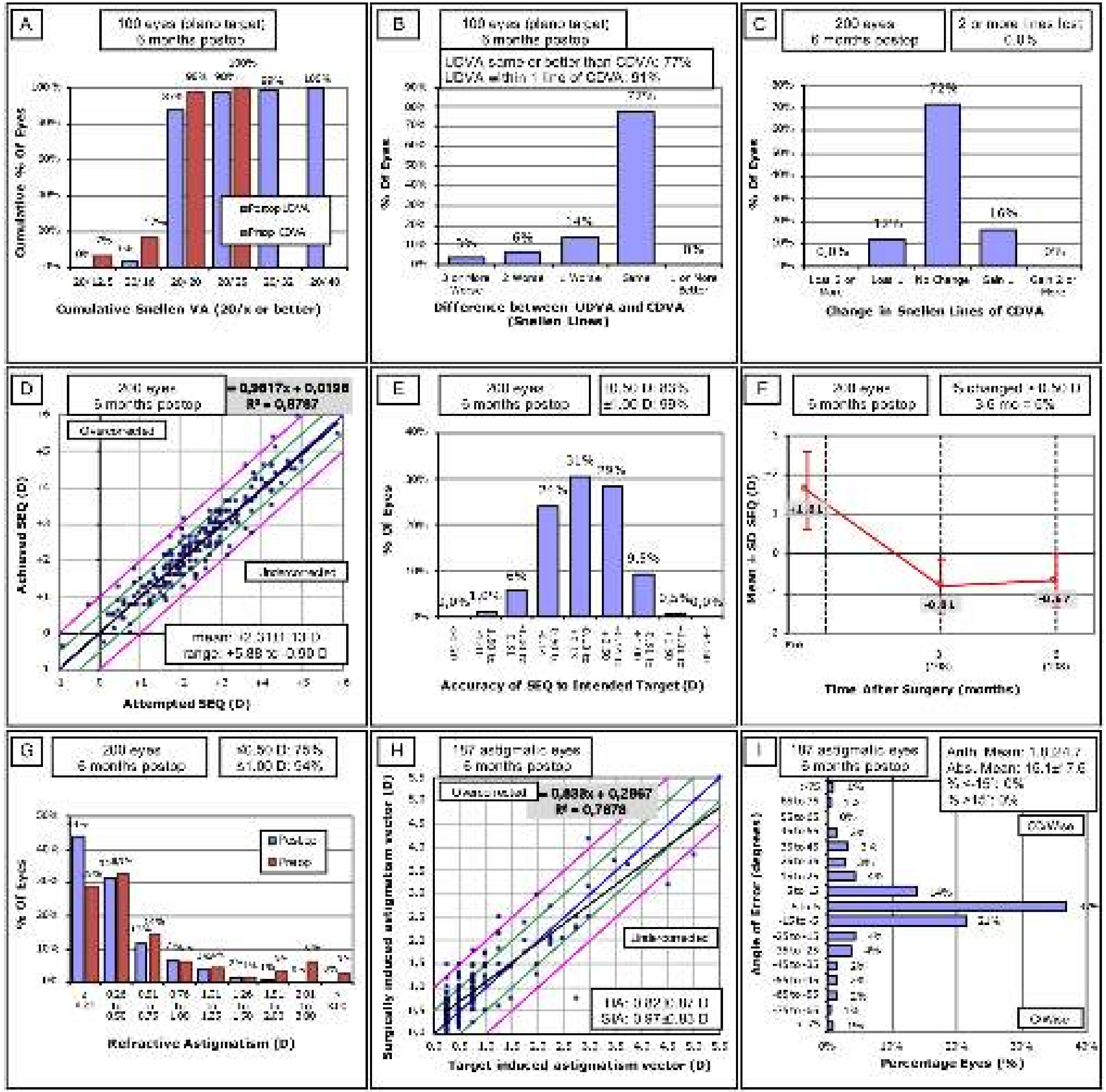




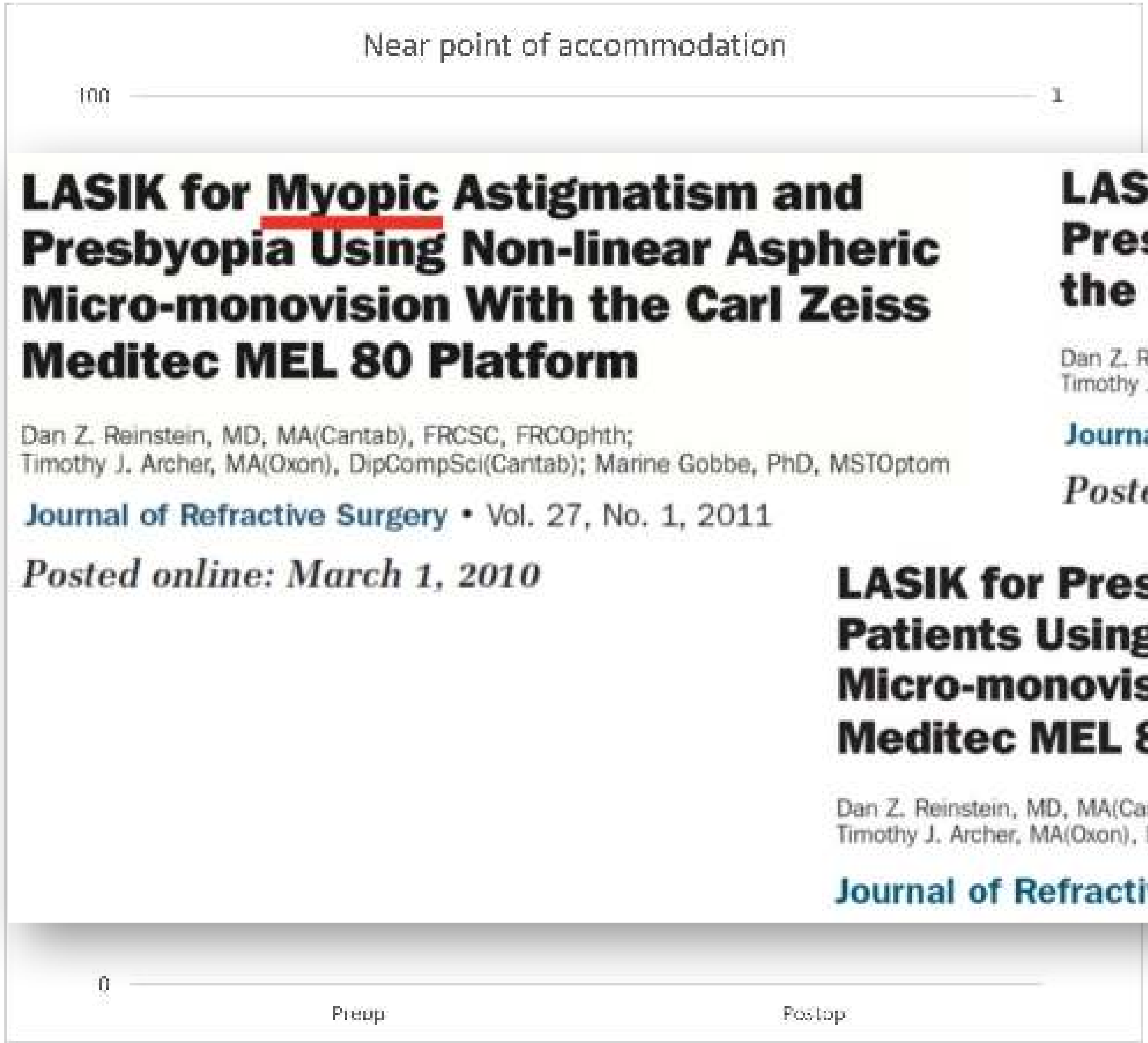
Age-Related Changes in Corneal Astigmatism. Xu Shao et al Journal of Refractive Surgery; Vol. 33, No. 10, pp 696–703July 18, 2017

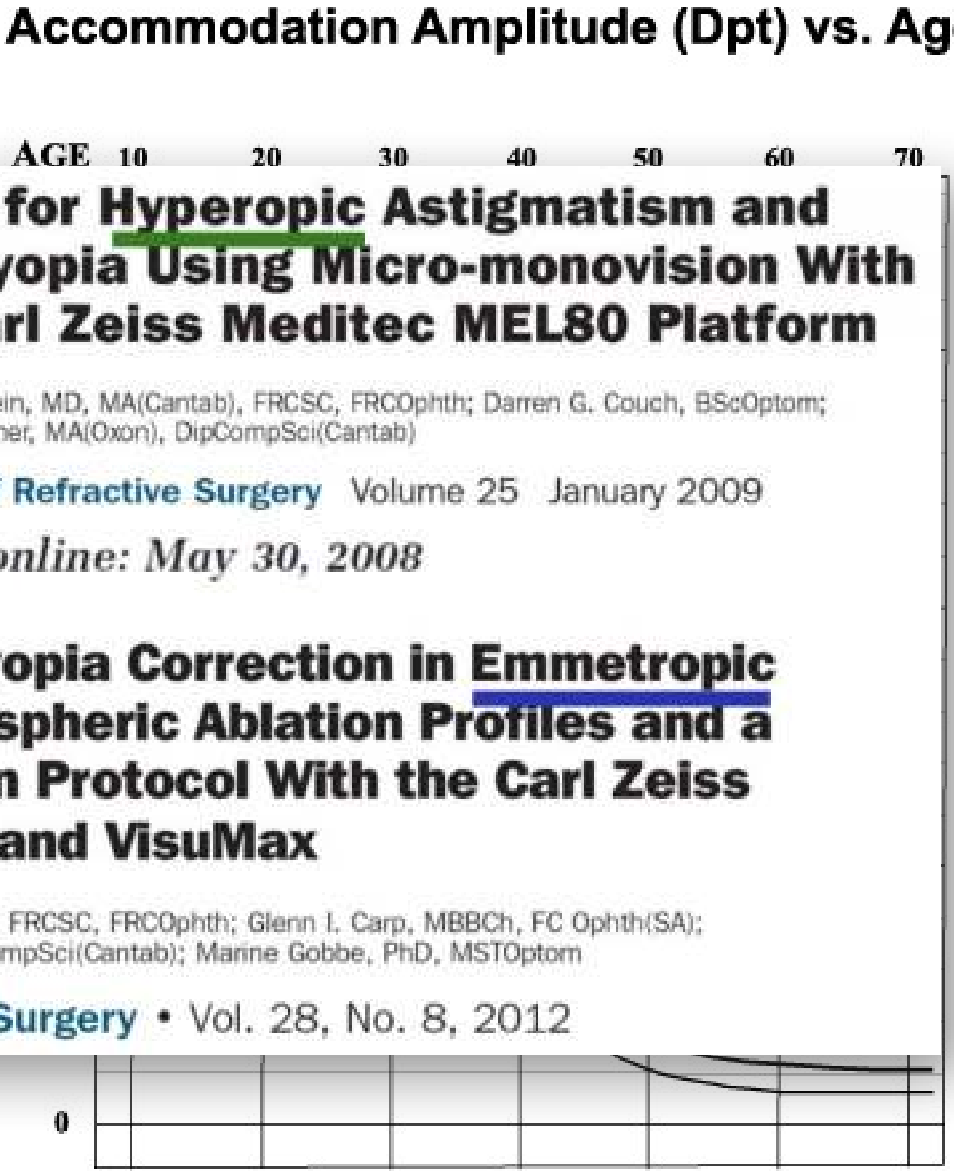


Andrea Russo, Dan Z Reinstein, Ottavia Filini, Timothy J Archer, Giulia Festa et al. *Journal of Refractive Surgery*



Andrea Russo, Dan Z Reinstein, Ottavia Filini, Timothy J Archer, Giulia Festa et al. *Journal of Refractive Surgery*





LASIK for Myopic Astigmatism and Presbyopia Using Non-linear Aspheric Micro-monovision With the Carl Zeiss Meditec MEL 80 Platform

Dan Z. Reinstein, MD, MA(Cantab), FRCSC, FRCOphth;
Timothy J. Archer, MA(Oxon), DipCompSci(Cantab); Marine Gobbe, PhD, MSTOptom

Journal of Refractive Surgery • Vol. 27, No. 1, 2011

Posted online: March 1, 2010

LASIK for Hyperopic Astigmatism and Presbyopia Using Micro-monovision With the Carl Zeiss Meditec MEL80 Platform

Dan Z. Reinstein, MD, MA(Cantab), FRCSC, FRCOphth; Darren G. Couch, BScOptom;
Timothy J. Archer, MA(Oxon), DipCompSci(Cantab)

Journal of Refractive Surgery Volume 25 January 2009

Posted online: May 30, 2008

LASIK for Presbyopia Correction in Emmetropic Patients Using Aspheric Ablation Profiles and a Micro-monovision Protocol With the Carl Zeiss Meditec MEL 80 and VisuMax

Dan Z. Reinstein, MD, MA(Cantab), FRCSC, FRCOphth; Glenn I. Carp, MBBCh, FC Ophth(SA);
Timothy J. Archer, MA(Oxon), DipCompSci(Cantab); Marine Gobbe, PhD, MSTOptom

Journal of Refractive Surgery • Vol. 28, No. 8, 2012