Spherical aberration after PresbyMax μ-monovision in different refraction types.

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Aberrations of the eye

There is a number of different aberrations in the eye, causing a non perfect focus of images on the retina. Important deviations include:

- spherical aberration (where the central light rays reaches a focus that is closer or farther to the cornea than the ray at the periphery), and
- chromatic aberration (where a ray of blue light reaches a focus that is closer to the cornea rather than a ray of red light).
- another aberrations which lead that the cornea focuses images onto a spherical surface rather than a flat surface.
Light distribution in different SA types

<table>
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<th>Inner Eye</th>
<th>Outer Eye</th>
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<td>Negative Spherical Aberration</td>
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<td>No Aberrations</td>
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Positive spherical aberration

Paraxial rays come to a point focus on the retina, light rays entering the peripheral cornea would be bent too much and would focus in front of the fovea (central point on the retina). These light rays can degrade contrast sensitivity and visual acuity when the pupil is enlarged, such as in low-light conditions.
Negative spherical aberration

- In this extreme prolate cornea, peripheral rays are not bent enough and focus at a virtual point behind the fovea, degrading image quality.
Age related changes of the spherical aberration
PresbyMAX® delivers **bi-aspheric multifocal ablation** profiles, creating **multifocal corneal surface**

The ablation profiles are based on a **light distribution algorithm**\(^1\)

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PresbyMAX® - Method of action

Refraction Targets for the central and pericentral areas

Distance Eye ("dominant")
-0.13D -1.38D
μ-Monovision
DoF 1.25D
Δ 0.75D

DoF reduced half
-0.13D -0.75D

Near Eye ("non-dominant")
-2.13D -0.88D
Hybrid
μ-Monovision

DoF equal
DoF_{DE} 0.63D
DoF_{NE} 1.25D
Δ_p 0.75D
Δ_c 1.38D
Components of the profile

- BI-ASPHERIC MULTIFOCAL PROFILE
- NEGATIVE SPHERICAL ABERRATION
- \( \mu \)-MONOVISION + HYBRID (ANISOMETROPIA)
- PUPIL MOBILITY DURING THE ACCOMODATION

INCREASING THE DEPTH OF FOCUS
The principle

PresbyMAX®
 multiaspheric cornea

Light distribution concept
Near distance: ~ 35 - 40%
Intermediate range: ~ 15%
Far distance: ~ 45 – 50%

extended depth-of-focus

PresbyMAX®
pseudo-far-point

PresbyMAX®
pseudo-near-point

foveola
Why “Negative” SA?

- Steep center is more natural, because when we read – pupil constricts
- Pupil natural mobility increases DoF in prolate corneas
- Lens with a large amount of spherical aberration more increases the depth of focus
- While accommodating, young eye creates additional negative SA
- Negative spherical aberration is most used in PesbyLasik and other presbyopia correcting approaches
• 31 (62 eyes) patients were operated
• Age 47±5 yo (40-59)
• 20 hyperopes and 11 myopes
• SE from +4.5 D to -6 D
• astigmatism up to 2 D
• mean CDVA 1.05 (decimal)

• near addition (40 cm) 1.95±0.54 D (+1.0 D to +3 D)
• Intermediate addition (70 cm) 1.2±0.27D
• pupil size 2.86 ± 0.17 mm in photopic conditions
• pupil size 5.03 ± 0.5 mm in scotopic conditions
• time of observation for 17 patients (34 eyes) is 6 months or more

PresbyMAX μ-Monovision bi-aspheric treatments were planned with Custom Ablation Manager software. Standard PRK treatment with use of Mitomycin C post laser ablation has been carried out in all cases.
Binocular DVA data 6-12 months postop

![Graph showing UDVA and CDVA for Myopia and Hyperopia](chart.png)
DUCVA correlation function
6-12 months postop

[Graph showing correlations with values 0.93, 0.87, 0.75, -0.62, -0.53]
Myopic patients reached anisometropia of 0.75±0.29 (6M) and 0.58±0.14 (12M) and Hyperopic patients reached anisometropia of 0.70±0.51 (6M) and 0.50±0.75 (12M).
Spherical aberration C (4,0) over time (6,0 mm)

**Bar Chart**

- **Myopia**
  - Myo Pre: 0.17
  - Myo Post 6M: 0.35
  - Myo Post 12M: 0.36

- **Hyperopia**
  - Hyp Pre: 0.24
  - Hyp Post 6M: -0.28
  - Hyp Post 12M: -0.16

Legend:
- NE
- DE
DVA is slightly higher in myopia group

SA does not influence on DUCVA in myopia patients, the most important factor for DUCVA - is SE (corr = 0.87)

SA and SE have strong positive correlation (0.93 and 0.75) with DUCVA in hyperopia patients

In hyperopia group in the negative SA could be decreased in DE to achieve higher DVA

Coma aberration value has a significant negative correlation (-0.53) with DUCVA in hyperopia group, thus “pupil shift” could be taken into account during the profile generation
SA influence on DoF

Magnitude spherical aberration (A)

J Cataract Refract Surg, November, 2009 Karolinne Maia Rocha, MD, PhD and Ronald R. Krueger, MD, MSE
Binocular NVA data 6-12 months postop
What is important?

- The mean maximum tolerated negative SA without loosing any letter in 20/20 is 
  
  \(-0.39 \mu\) giving 0.39D depth of focus in real eye!!

- Patient’s individual pupil size is not associated with the Negative SA tolerance.

- Relation between spherical aberration and myopic defocus:

  \[ C_{2,0} = \sqrt{3} \sqrt{5} S^2(S^2-1) C_{4,0} \]

  where S-pupil constriction

J Cataract Refract Surg, November, 2009 Karoline Maia Rocha, MD, PhD and Ronald R. Krueger, MD, MSE
How does the pupil size affecting DoF?

SA -0.6μm

6 mm  4 D
4.5 mm  4.5 D
3 mm  5.75 D

SA +0.6μm

6 mm  3.5 D
4.5 mm  3.9 D
3 mm  4.5 D

“ - ”

D

“ + ”
Photopic pupil size

![Graph showing photopic pupil size before operation, 6 months postoperation, and 12 months postoperation.](image)
NUCVA correlation function
• NVA is slightly higher in myopia group, even they did not achieve negative SA (mean for DE = 0.28, for NE = 0.35) SA has a poor positive correlation with NUCVA (0.34) in this group!!

• The most important factor, influencing NUCVA in myopia group is SE (corr= -0.57), NVA in this group was high enough

• Negative SA was achieved in hyperopia group (mean for DE = -0.13, for NE = -0.28)

• SA has a significant negative correlation with NUCVA in Hyperopia group (-0.49) - so it should be preserved for NE
Intermediate note

- Pupil reaction in hyperopic patients is more significant than in myopic, which additionally increases the DoF, especially in NE.
- DoF can be improved in near eye for hyperopic patients (Hybrid approach).
- SE strongly influencing on NUCVA in hyperopia group: SE (corr = -0.61), thus the nomogram could be improved in NE (Hybrid approach).
Summary

- PresbyMax μ-Monovision Hybrid approach could be recommended for both myopic and hyperopic patients – allowing to achieve an optimal target SE in DE and NE.

- The role of SA in correction Presbyopia in Myopic patients should be investigated during long time observation.

- The role of pupil size in achieved results should be investigated.

- Factors should be also taken into account are: Total WF aberrations, peripheral defocus and pupil accommodative reaction.

Thank you for your kind attention!