Effects of Zernike Wavefront Aberrations on Visual Acuity measured using Electromagnetic Adaptive Optics Technology

Karolinne Maia Rocha, MD
Laurent Vabre, PhD
Jean-Luc Nguyen Khoa, MD
Nicolas Chateau, PhD
Ronald Krueger, MD
Purpose

To measure the changes in visual acuity induced by various amounts of single Zernike aberrations
Methods

crx1 Adaptive Optics Visual Simulator
(Imagine Eyes, Orsay, France)

software kit:
• irx3 aberrometer software
• SVAO wavefront builder
• CSO adaptive optics software
• wavefront stroke 50µm
Methods

• 10 eyes (10 subjects);
• 1 eye excluded;
• initial measurement of the total ocular aberrations;
• static compensation for wavefront error;
• application of pure Zernike aberrations;
Methods

Pupil tracker

Badal system

IR diodes

Wavefront sensor

Microdisplay

Wavefront measurement

Deformable mirror
Methods

Pupil tracker

Badal system

IR diodes

Wavefront sensor

Microdisplay

Deformable mirror

Static correction and Zernike generation
Methods

Pupil tracker

Badal system

IR diodes

Wavefront sensor

Microdisplay

Visual stimulation

Deformable mirror
Methods

Visual Acuity:

Freiburg Acuity Test
- Landolt C
- 8 directions
- 18 presentations

50 cd/m²
Methods

Simulator pupil diameter: adjusted to 5mm

Applied aberrations:

• none (uncorrected)
• sph/cyl correction
• full correction (2nd to 5th orders)
• full correction + single Zernike modes
Results

Comparison between best sphero-cyl and full AO correction

![Graph showing comparison between best sphero-cyl and full AO correction.](image-url)
Results

Comparison between best spherocyl and full AO correction

![Graph showing comparison between best spherocyl and full AO correction. The graph displays the VA (LogMAR) for SPHERO-CYL and FULL correction, with error bars indicating the mean ±SE and ±SD.](image)
Results

Is the improvement in VA with full AO correction related to the preexisting amount of HOAs?
Methods

Zernike generation:

RMS 0.1 µm, 0.3 µm, 0.9 µm

- defocus $Z(2,0)$
- astigmatism $Z(2,2)$
- coma $Z(3,1)$
- trefoil $Z(3,3)$
- spherical aberration $Z(4,0)$
Results

Defocus Z(2,0)

Change in VA (LogMAR)

RMS aberration (µm)
Results

Astigmatism Z(2,-2)

Change in VA (LogMAR)

RMS aberration (µm)
Results

Coma Z(3,-1)

<table>
<thead>
<tr>
<th>Change in VA (LogMAR)</th>
<th>RMS aberration (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.2</td>
<td>0.0</td>
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<tr>
<td>0.0</td>
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<tr>
<td>0.2</td>
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<td>0.6</td>
<td>0.8</td>
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<tr>
<td>0.8</td>
<td>1.0</td>
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</table>

Mean ±SE ±SD
Results

Trefoil Z(3,-3)

RMS aberration (µm)

Change in VA (LogMAR)
Results

Spherical aberration $Z(4,0)$

Change in VA (LogMAR)

RMS aberration ($\mu$m)

-0.2
0.0
0.2
0.4
0.6
0.8
1.0

0.1
0.3
0.9

Mean
±SE
±SD
Results

Coefficient 0.1 µm

Change in Aberration mode

Defoc Asti Coma Trefoil S.A.

Mean ±SE ±SD
Results

Coefficient 0.3 μm

Change in Aberration mode

Defoc  Asti  Coma  Trefoil  S.A.
Results

Coefficient 0.9 µm

Change in Aberration mode

Mean ±SE ±SD
Conclusion

• The static correction of HOA improved visual acuity by one line in average, compared to sphero-cylinder correction.

• The generation of different Zernike aberrations of equal RMS resulted in different changes in VA.

• The more central aberrations in the Zernike pyramid, e.g. defocus and spherical aberration, had more detrimental effect on VA.

• Neural Adaptation could impact the difference in visual improvement with HOA compensation between subjects.