Comparison of Optical Quality Metrics to Predict Subjective Quality of Vision after LASIK

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Background

stimulus (object)  →  image

anatomy  →  optical properties  →  function  →  (subjective) perception

resolution  
contrast sensitivity

e
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Objective

• What image quality metric / wavefront error representation is capable best of predicting subjective Quality of Vision?
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• What image quality metric / wavefront error representation is capable best of predicting subjective Quality of Vision?

• How could predictability be increased?
Patients: preop data

- **56 eyes** of 29 patients with **LASIK for Myopia**
  - 51 eyes (26 patients Zyoptix 5.09 with static iris recognition)
  - 5 symptomatic eyes with LASIK elsewhere
- **age** 36.5 years (24 to 55 years)
- **preop Rx**
  - median SE -4.88 D (-1.63 to -8.25 D)
  - median sphere -4.25 D (-1.50 to -4.25 D)
  - median cylinder -0.75 D (0.74 to -4.0 D)
Patients and Methods

- **Aberrometry** 1 month postoperatively
  - Hartmann-Shack sensor (Zywave™, B & L)

- **Questionnaire** 1 month postoperatively
  - rating of „optical quality“ for **three illuminance levels**:
    - photopic („bright light“)
    - high-mesopic („indoors“)
    - low-mesopic („dusk“)
  - visual analogue scale 0-100
Methods: WFE representation

- **Zernike decomposition** (6 mm) of the WFE up to the 5\textsuperscript{th} order (monochromatic [555 nm])
- **different WFE representations** (wavefront shape)
  - LOA RMS and HOA RMS
Methods: WFE representation

- **Zernike decomposition** (6 mm) of the WFE up to the 5\textsuperscript{th} order
- **different WFE representations (wavefront shape)**
  - LOA RMS and HOA RMS
  - LOA RMS, coma RMS, \(Z_4^0\) and residual HOA RMS (LCSR)
Methods: WFE representation

- **Zernike decomposition** (6 mm) of the WFE up to the 5\textsuperscript{th} order
- **PSF-based single-value metrics**
  - Strehl ratio (SR)
  - Volume under the cross correlation coefficient function (VXC)

![Graph showing log cross correlation coefficient vs optotype size (logMAR)](image)
Methods: WFE representation

- **Zernike decomposition** (6 mm) of the WFE up to the 5\textsuperscript{th} order
- PSF-based single-value metrics
  - Strehl ratio (SR)
  - volume under the cross correlation coefficient function
- **OTF-based single-value metrics**
  - volume under the MTF (VMTF)
  - Strehl ratio based on the volume under the MTF (SRMTF)
  - visual Strehl ratio based on the OTF (VSOTF)
Methods: WFE representation

• **different conditions/simulations:**
  – lighting conditions „photopic“, „high-“ and „low-mesopic“
  – uncorrected / best-corrected (VSOTF-based or HOA RMS)
  – 6 mm PD / physiological PD (0.4 lux)
Methods: statistical analysis

- **linear regression analysis**
  - SQV: dependent
  - WFE parameters: predictors
  - if more than one predictor: MRA w/ backwards decomposition
  - $R^2$ (coefficients of determination)
Results: SQV

Pearson matrix

<table>
<thead>
<tr>
<th></th>
<th>hi-mes</th>
<th>lo-mes</th>
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<tbody>
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<tr>
<td>hi-mes</td>
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Results: $R^2$ values (6 mm PD)
Results: $R^2$ values (6 mm PD)

![OTF-derived](image)
Results: mean $R^2$ values (6 mm PD)
Results: $R^2$ values 0.4 lux

![Graph showing $R^2$ values for different metrics like wavefront shape, PSF, and OTF.](image-url)
Summary / Discussion

- The influence of the postoperative WFE on SQV was limited (max. 23%)
- skewed distribution of SQV scores
Summary / Discussion

• almost “universal” performance under different lighting conditions (high correlation between SQV for different luminance conditions)
• no improvement of computation of physiological WFEs

- Adding additional variance
- More information in a 6 mm WFE
Conclusion – Take home messages

- high theoretical OQ = good subjective OQ
- bad subjective OQ = low theoretical OQ
- bad theoretical OQ = not necessary bad subjective OQ
Danke ! Thank you !
Summary / Discussion

- higher predictability for best-corrected values @ 6mm

- Higher tolerance to LOA blur?