Clinical Benefit of Compensation for Cyclorotation and Pupil Centroid Shift

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Background

- Pupil centroid shifts with change in size
  - Mesopic – wavefront measurement
  - Photopic – laser treatment
- Cyclotorsional rotation occurs with position change:
  - Sitting – wavefront measurement
  - Supine – laser treatment
- Clinical improvements with compensation for pupil centroid shifts and cyclotorsional rotation?
Purpose

🌟 To investigate the residual wavefront aberrations induced by the pupil centroid shift and cyclotorsional rotation and their clinical impact
Iris Registration

- 64 eyes of 40 patients treated with IR enabled
  - Magnitude of pupil center adjustment: 0.27 mm
  - Cyclotorsional compensation: 2.1°

![Graph showing pupil center adjustment and cyclotorsional compensation](image)
Theoretical Analysis

Residual aberrations (6-mm pupil) were calculated (VOLCT) from corneas of 50 eyes of 50 subjects for treatments with:

- 0.27 mm horizontal pupil centroid shift
- 2.1° counter-clockwise rotation

Parameters analyzed:

- Root-mean-square (RMS) of total (2nd to 6th) and higher-order (3rd to 6th) aberrations
- Strehl ratio (2nd to 6th)
Pupil shift

Rotation

* Significantly different from zero ($P<0.05$ with Bonferroni correction)
RMS of residual aberrations (µm)

Significantly higher RMS values induced by pupil centroid shift (All $P<0.001$)
Strehl ratio of residual aberrations

<table>
<thead>
<tr>
<th></th>
<th>Decentration (0.27 mm)</th>
<th>Rotation (2.1°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.40</td>
<td>0.79</td>
</tr>
<tr>
<td>SD</td>
<td>0.09</td>
<td>0.17</td>
</tr>
<tr>
<td>Range</td>
<td>0.28 to 0.75</td>
<td>0.34 to 0.98</td>
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</tbody>
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Significantly lower Strehl ratio values induced by pupil centroid shift ($P<0.001$)
Strehl ratio as a function of keratometric cylinder

Correlation coefficient $r = -0.944$ for rotation ($P < 0.001$), and $r = -0.016$ for decentration ($P = 0.91$)
Clinical Impact

- 7 subjects were treated with IR in 1 eye and without IR in the other eye (CV-LASIK for 5 subjects and CV-PRK for 2 subject)
- Aberrations were scaled to the smaller pupil size of the 2 eyes for each subject for valid comparison
Subject #2:

OD - IR eye

OS – Non-IR eye

Scaling OS pupil size to 6.25 mm, HOA RMS was 0.70 µm vs. 0.44 µm in OD
5 of the 7 subjects had lower HOA RMS in the IR eyes.
Normalized Polar Zernike Coefficients (CV)
**HOA RMS and 3\textsuperscript{rd}-order coma (\(\mu m\))**

<table>
<thead>
<tr>
<th></th>
<th>IR</th>
<th>Non-IR</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOA RMS</td>
<td>0.32 ± 0.11</td>
<td>0.39 ± 0.18</td>
<td>0.07 ± 0.11</td>
</tr>
<tr>
<td>3\textsuperscript{rd}-order coma</td>
<td>0.14 ± 0.06</td>
<td>0.22 ± 0.14</td>
<td>0.08 ± 0.15</td>
</tr>
</tbody>
</table>

No statistically significant differences between IR and non-IR eyes (both \(P>0.05\))
Conclusion

🌟 Theoretical analysis:

♦ For normal eyes with astigmatism <2D, pupil centroid shift feature provides greater visual benefit

♦ For eyes with astigmatism >2D, cyclotorsional rotation registration provides comparable or greater visual benefit
Conclusion

**Clinical Impacts:**

- Small sample of cases showed trend of lower HOA and coma in IR eyes
- Study is ongoing to enroll large number of subjects to investigate the clinical impact of pupil centroid shift and rotation compensation
Thank you for your attention