Biomechanically Induced Aberrations from Horizontal Corneal Incisions (Flaps)

Ronald R. Krueger, MD
Biomechanical Shifts Increase Following Deep Laser Treatment

Flap Induced Aberrations


Flap Induced Aberrations


Our Study of Flap Induced Aberrations

We measure ocular aberrations with:

- LADARWave
  – Flap Only Eyes using:
  – Moria M2  - SKBM
Flap Study Design

22 eyes

- 10 eyes **SKBM**: nasal flap
  - 162 ± 21 um

- 12 eyes **Moria M2**:
  - 6 eyes nasal flap
  - 6 eyes superior flap
  - 130 ± 22 um
Flap Study Design

- Pre-operative .................. Flap Created
- 1 day Post Flap
- 1 week Post Flap
- 1 month Post Flap .......... Flap Lifted & Laser
- 1 day Post Laser
- 1 week Post Laser
- 3 months Post Laser
Flap study Early Results

- Flap Aberrations depend on microkeratome type, flap thickness profile and hinge location
- **Early**: Flap swelling is present in 1st day w/ variable change in sphere
- With time, sphere changes in hyperopic shift
- **Early**: +Coma tends to shift to hinge w/ Moria
- **Early**: -Coma tends to shift to hinge w/ SKBM
Flap study Results

• A **statistically significant** increase in flap induced **total high order aberrations** and **other terms** and **spherical aberration** at both 1 week & 1 month for the two types of microkeratomes used regardless of hinge position placement.

• A **statistically significant hyperopic shift** after making the flap was noted in the **manifest refraction (~0.5 D)** for Moria M2.
Flap Induced Hyperopia (Manifest Refraction)

### Table 1: Effect of type of microkeratome on manifest sphere at 1 week post flap creation

<table>
<thead>
<tr>
<th>Microkeratome</th>
<th>N</th>
<th>Pre-op</th>
<th>1 week post flap</th>
<th>Mean Diff.</th>
<th>Std. Error</th>
<th>Flap Thickness Mean +/- SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moria M2</td>
<td>12</td>
<td>-4.35</td>
<td>-3.83</td>
<td>0.52</td>
<td>0.08</td>
<td>142 +/- 24</td>
<td>0.001</td>
</tr>
<tr>
<td>SKBM</td>
<td>10</td>
<td>-4.35</td>
<td>-4.33</td>
<td>0.03</td>
<td>0.14</td>
<td>169 +/- 27</td>
<td>0.87</td>
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</tbody>
</table>

### Table 2: Effect of type of microkeratome on manifest sphere at 1 month post flap creation

<table>
<thead>
<tr>
<th>Microkeratome</th>
<th>N</th>
<th>Pre-op</th>
<th>1 week post flap</th>
<th>Mean Diff.</th>
<th>Std. Error</th>
<th>Flap Thickness Mean +/- SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moria M2</td>
<td>12</td>
<td>-4.35</td>
<td>-3.83</td>
<td>0.50</td>
<td>0.08</td>
<td>142 +/- 24</td>
<td>0.003</td>
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<tr>
<td>SKBM</td>
<td>10</td>
<td>-4.35</td>
<td>-4.72</td>
<td>0.06</td>
<td>0.17</td>
<td>169 +/- 27</td>
<td>0.73</td>
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</table>
## Flap Induced Aberrations

### 1 wk

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>Std. Error</th>
<th>P - value</th>
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<tbody>
<tr>
<td>Total Aberrations</td>
<td>22</td>
<td>0.09</td>
<td>0.01</td>
<td><strong>0.010</strong></td>
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<tr>
<td>Vertical Coma</td>
<td>22</td>
<td>0.00</td>
<td>0.03</td>
<td>0.90</td>
</tr>
<tr>
<td>Horizontal Coma</td>
<td>22</td>
<td>0.03</td>
<td>0.03</td>
<td>0.34</td>
</tr>
<tr>
<td>Sph. Aberration</td>
<td>22</td>
<td>0.06</td>
<td>0.02</td>
<td><strong>0.033</strong></td>
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<tr>
<td>Other terms</td>
<td>22</td>
<td>0.05</td>
<td>0.01</td>
<td><strong>0.005</strong></td>
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</table>

Table 3: Changes in higher order aberrations from pre-op to 1 week post-flap

### 1 mo

<table>
<thead>
<tr>
<th>Variable</th>
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<tr>
<td>Total Aberrations</td>
<td>22</td>
<td>0.08</td>
<td>0.02</td>
<td><strong>0.004</strong></td>
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<tr>
<td>Vertical Coma</td>
<td>22</td>
<td>-0.01</td>
<td>0.02</td>
<td>0.79</td>
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<td>Horizontal Coma</td>
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<td>0.03</td>
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<td>0.27</td>
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<td>Sph. Aberration</td>
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<td><strong>0.008</strong></td>
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<td>Other terms</td>
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<td>0.05</td>
<td>0.01</td>
<td><strong>0.004</strong></td>
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Table 4: Changes in higher order aberrations from pre-op to 1 month post-flap
### Flap to Laser Change in Aberrations

<table>
<thead>
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</thead>
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<td>0.10</td>
<td>0.002</td>
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<td>Vertical Coma</td>
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<td>0.16</td>
<td>0.05</td>
<td>0.013</td>
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<td>Horizontal Coma</td>
<td>22</td>
<td>0.11</td>
<td>0.03</td>
<td>0.10</td>
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<tr>
<td>Sph. Aberration</td>
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<td>0.38</td>
<td>0.09</td>
<td>0.002</td>
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<tr>
<td>Other terms</td>
<td>22</td>
<td>0.08</td>
<td>0.02</td>
<td>0.009</td>
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</table>

#### Table 5: Changes in higher order aberrations from pre-op to 1 week post-laser

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>Std. Error</th>
<th>P - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Aberrations</td>
<td>22</td>
<td>0.33</td>
<td>0.09</td>
<td>0.004</td>
</tr>
<tr>
<td>Vertical Coma</td>
<td>22</td>
<td>0.17</td>
<td>0.07</td>
<td>0.027</td>
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<tr>
<td>Horizontal Coma</td>
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<td>0.08</td>
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<td>Sph. Aberration</td>
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<td>0.31</td>
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<td>Other terms</td>
<td>22</td>
<td>0.03</td>
<td>0.03</td>
<td>0.31</td>
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</tbody>
</table>

#### Table 6: Changes in higher order aberrations from 1 month post-flap to 3 month post laser
Although significant, Flap changes are much smaller than Laser Changes.

Effect of Flap Creation and Laser on Coma

Change in Total Higher Order Aberrations over time.

Change in Sph. Aberration and Other Terms over time
Study Summary

- The amount of higher order aberration (RMS) **does** change significantly after the flap cut.
- Laser treatment **increases** aberrations, especially spherical aberration, **to a much larger degree than those induced by the flap**, so that 2-Step LASIK is not essential.
Microkeratome + Laser Ablation

More Collagen Cutting causes
More Fiber Retraction yielding
More Peripheral Thickening
+ Central Flattening

= ↑ Spherical Aberration
+ Hyperopic Shift
What’s Next?....... Femtosecond Laser Flaps!

• **IntraLase** shows a *reduction* in flap induced aberrations in comparison to microkeratomes *(Tran, et al. J Cataract Refract Surg 2005; 31:97-105)*.

So, We Decided to Perform Our Own Analysis!

Purpose

Evaluate the wavefront outcomes of the patients undergone LASIK with mechanical microkeratomes vs the femtosecond laser
Flap Biomechanical Study

• Retrospective analysis of LASIK.
• N= 410 myopic patients (Moria M2 #205, Hansa #51, IntraLase (15 & 30 KHz) #154).
• One eye per patient was randomly selected.
• Preop and 3 month Postop Aberrations captured by LADARWave at 6.5 mm pupil.
• Subjects were compared by keratome and according to refractive error and aberration.
Design

• Change in intended direction was used to grade the Zernike polynomial modification vs the correction attempted or the aberration pre-op value in:

• **Improvement**: if the change occurred toward the zero (positive value)

• **Deterioration**: the post-op value had a movement away from zero (negative value).
Aberration value change

Considered a positive change
“Improvement in the Post-op period”

Considered a negative change
“Deterioration in the Post-op period”
Comparative Flap Analysis:

**IntraLase** — Uniform Profile

- **Microkeratomes** are thicker in the periphery & thinner in the center

**Target 180 microns**

- Central: 128µ, Range 61-90µ
- Inferior: 161µ, Range 87-272µ
- Superior: 164µ, Range 87-272µ

J. Doane, MD: Hansatome study of central and peripheral pachymetry
The Higher the Myopia, the greater the inducement Of Higher Order Aberration
HOA Change

Femtosecond is statistically better than the other two groups (IL vs H p=0.014, IL vs M p<0.001).

Hansa and Moria presented similar results (H vs M p=0.23).

The Higher the Myopia, the greater the inducement of HOAs

**Myopic Correction**

- **Moria**
  - Mean HOA ↓
  - With > 1.75 D

- **IntraLase**
  - Mean HOA ↑
  - With > 3.25 D

**Graph:**
- H-LASIK (Red)
- M-LASIK (Green)
- IL (Blue)

**Legend:**
- **Better**
- **Worse**
- **Post – Pre MR Spherical Equivalent**
- **Myopic Correction**

**Statistics:**
- IL vs H p=0.014
- IL vs M p<0.001
- H vs M p=0.23
Spherical Aberration Change

Femtosecond group is statistically better than the other two (IL vs H p=0.015, IL vs M p<0.001).

Hansa tends to be better than Moria (H vs M p=0.052).

The Higher the Myopia, the greater the inducement of Spherical Aberration.
Coma Change

There is not difference among the groups (IL vs H p=0.21, IL vs M p=0.14 and H vs M p=0.89).

The Higher the Myopia, the greater induction of Coma

Myopic Correction
HOA Change vs PreOp Magnitude

Femtosecond is statistically better than the Moria groups (IL vs M p<0.001)
Femto and Hansa are not statistically different (IL vs M, p=0.10)

HOA Change increases with low PreOp HOA, but decreases when higher

Better
Worse
Spherical Aberration Change vs PreOp Magnitude

Femtosecond group is statistically better than the other two
(IL vs H $p=0.015$, IL vs M $p<0.001$).

IntraLase Progressively Lowers the Spherical Aberration Change, while Hansa and Moria Don’t

\[ \approx 0.38 \]
**Total Aberrations Pre-op vs. Post-op Improvement**

Femtosecond and Hansa lines are not statistically different (IL vs H $p=0.53$). Moria group had worse results compared to the other two, mainly in high Pre-op values (H vs M $p=0.001$ and M vs IL $p<0.001$).
Study Summary

Overall, with wavefront-guided customized LASIK, the IntraLase demonstrated better aberration outcomes & change in:

- Higher order aberrations
- Spherical aberration
- Total aberrations

......when compared to mechanical microkeratomes.
Mechanical vs IntraLase Flaps

Images provided by Dr. Richard Foulkes
Morphological Flap Changes can cause Biomechanical Shifts

- Femtosecond Laser
  - Planar Flap
- Conventional Microkeratome
  - Meniscal Flap
IntraLASIK vs. Microkeratome Flaps

Flap Only Sub-Study: Flap first/ Laser later

- 2 Patients (4 Eyes) are reviewed in detail to understand the connection between flap creation & the induction of optical aberrations
Patient #1 -KR

- 45 yo female graphic designer enrolled in a flap only study, Pachs

- MR: -2.25 -2.75 x01 (20/15) OD 575 um
  -2.50 -2.50 x180 (20/15) OS 574 um

- K’s: 44.75/41.87 @90 OD
  46.12/43.50 @84 OS

- CR: -1.75 -2.75 x179 OD
  -2.25 -2.25 x05 OS

- WR: -2.08 -2.89 x02 OD
  -2.19 -2.33 x08 OS
Patient #1 - KR

- Flap Surgery Date: November 23, 2004
- **OD:** Moria M2
  - 90 um head
  - 0 ring
  - Flap thickness=93
- **OS:** IntraLase
  - 90 um setting
  - 2.0 uJ raster energy
  - 11/9 um pattern
  - Flap thickness=122
Artemis Thickness Profile

**Fig 1a**
- IntraLase 90 um
- 98, 101, 113

**Fig 1b**
- Moria M2 90 head
- 147, 75, 167

---

IntraLase 90 um
Moria M2 90 head
Patient #1 – KR
Post Flap Biomechanics: 1 month

- OD: Moria M2
- OS: IntraLase

Peripheral Steepening = Spherical Aberration ~2.0 D
Central Flattening
Patient #1 – KR
Post Flap Biomechanics: 1 month

- OD: Moria M2
- OS: IntraLase

Pre MR: -2.25 -2.75 x 01
1moMR: -1.50 -3.00 x 177
+0.75

Pre WR: -2.08 -2.89 x 02
1moWR: -1.56 -2.88 x 179
+0.52

Pre MR: -2.50 -2.50 x 180
1moMR: -2.25 -2.50 x 179
+0.25

Pre WR: -2.19 -2.33 x 08
1moWR: -1.83 -2.27 x 01
+0.36
### Patient #1 – KR

**Post Flap Biomechanics: 1 month**

- **OD:** Moria M2
- **OS:** IntraLase

<table>
<thead>
<tr>
<th>Aberrations</th>
<th>RMS (microns)</th>
<th>Aberrations</th>
<th>RMS (microns)</th>
<th>Aberrations</th>
<th>RMS (microns)</th>
<th>Aberrations</th>
<th>RMS (microns)</th>
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<tbody>
<tr>
<td>Defocus</td>
<td>5.56</td>
<td>Defocus</td>
<td>4.91</td>
<td>Defocus</td>
<td>5.55</td>
<td>Defocus</td>
<td>5.00</td>
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<tr>
<td>Astigmatism</td>
<td>2.60</td>
<td>Astigmatism</td>
<td>2.68</td>
<td>Astigmatism</td>
<td>2.23</td>
<td>Astigmatism</td>
<td>2.02</td>
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<tr>
<td>Coma</td>
<td>0.13</td>
<td>Coma</td>
<td>0.15</td>
<td>Coma</td>
<td>0.16</td>
<td>Coma</td>
<td>0.13</td>
</tr>
<tr>
<td>Spherical Aberration</td>
<td>0.11</td>
<td>Spherical Aberration</td>
<td>0.16</td>
<td>Spherical Aberration</td>
<td>0.15</td>
<td>Spherical Aberration</td>
<td>0.17</td>
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<tr>
<td>Other</td>
<td>0.22</td>
<td>Other</td>
<td>0.26</td>
<td>Other</td>
<td>0.25</td>
<td>Other</td>
<td>0.36</td>
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</table>

**Pre MR:** -2.25, -2.75 x 01  
**1moMR:** -1.50, -3.00 x 177  
**Pre WR:** -2.08, -2.89 x 02  
**1moWR:** -1.56, -2.88 x 179  

**Pre MR:** -2.50, -2.50 x 180  
**1moMR:** -2.25, -2.50 x 179  
**Pre WR:** -2.19, -2.33 x 08  
**1moWR:** -1.83, -2.27 x 01  

- **OD:** +0.75
- **OS:** +0.52

- **OD:** +0.25
- **OS:** +0.36
Patient #2 - ED

- 36 yo female graphic designer enrolled in a flap only study,
- MR: -6.00 -1.00 x179 (20/15) OD
  -6.50 -1.00 x162 (20/15) OS
- K’s: 45.25/44.25@100 OD
  45.37/44.12@92 OS
- CR: -5.75 -1.25 x01 OD
  -6.50 -1.00 x163 OS
- WR: -5.88 -1.30 x179 OD
  -6.52 -0.76 x168 OS
Patient #2 - ED

- Flap Surgery Date: March 24, 2005

- **OD:** IntraLase
  - 100 um setting
  - 1.6 um raster energy
  - 9/9 um pattern
  - Flap thickness=142

- **OS:** Moria M2
  - 90 um head
  - 0 ring
  - Flap thickness=102
Patient #2 – ED
Post Flap Biomechanics: 1 week

• OD: IntraLase
• OS: Moria M2

Peripheral Steepening = Spherical Aberration
0 to 1.0 D ~2.0 D
Patient #2 – ED

Post Flap Biomechanics: 1 month

• OD: IntraLase
• OS: Moria M2

Peripheral Steepening = Spherical Aberration

0.5 to 1.0 D

~2.0 D
Patient #2 – ED

Post Flap Biomechanics: 1 month

- OD: IntraLase
- OS: Moria M2

<table>
<thead>
<tr>
<th>Eye (OD)</th>
<th>March 16, 1 Eye (OD)</th>
<th>Elizabeth Dinvald</th>
<th>April 21</th>
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<tbody>
<tr>
<td>Refraction from Wavefront</td>
<td>Aberrations</td>
<td>RMS (microns)</td>
<td>Refraction from Wavefront</td>
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<tr>
<td>Sphere</td>
<td>-5.67 Diopters</td>
<td>Defocus</td>
<td>0.26</td>
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<tr>
<td>Cylinder</td>
<td>-1.17 Diopters</td>
<td>Astigmatism</td>
<td>0.27</td>
</tr>
<tr>
<td>Axis</td>
<td>179 Degrees</td>
<td>Corneal</td>
<td>0.17</td>
</tr>
<tr>
<td>Magnification</td>
<td>95%</td>
<td>Diameter</td>
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<tr>
<td>Diameter</td>
<td>6.50mm</td>
<td>Other</td>
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Pre MR: -6.00 -1.00 x179
1moMR: -5.75 -1.00 x 02
Pre WR: -5.88 -1.30 x179
1moWR: -5.58 -1.48 x178

<table>
<thead>
<tr>
<th>Eye (OS)</th>
<th>March 16, 1 Eye (OS)</th>
<th>Elizabeth Dinvald</th>
<th>April 21</th>
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<td>Aberrations</td>
<td>RMS (microns)</td>
<td>Refraction from Wavefront</td>
</tr>
<tr>
<td>Sphere</td>
<td>-6.50 Diopters</td>
<td>Defocus</td>
<td>0.41</td>
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<tr>
<td>Cylinder</td>
<td>-0.77 Diopters</td>
<td>Astigmatism</td>
<td>0.36</td>
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<tr>
<td>Axis</td>
<td>172 Degrees</td>
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<td>0.94</td>
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<tr>
<td>Magnification</td>
<td>95%</td>
<td>Spherical Aberration</td>
<td>+0.30</td>
</tr>
<tr>
<td>Diameter</td>
<td>6.50mm</td>
<td>Other</td>
<td>+1.00</td>
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Pre MR: -6.50 -1.00 x162
1moMR: -5.50 -1.00 x163
Pre WR: -6.52 -0.76 x168
1moWR: -5.58 -1.45 x167

+1.00
+0.94
Patient #2 – ED

Post Flap Biomechanics: 1 month

- OD: IntraLase
  - Pre MR: -6.00 -1.00 x 179
  - 1mo MR: -5.75 -1.00 x 02 +0.25
  - Pre WR: -5.88 -1.30 x 179
  - 1mo WR: -5.58 -1.48 x 178 +0.30

- OS: Moria M2
  - Pre MR: -6.50 -1.00 x 162 +1.00
  - 1mo MR: -5.50 -1.00 x 163
  - Pre WR: -6.52 -0.76 x 168
  - 1mo WR: -5.58 -1.45 x 167 +0.94
Patient #1 – KR
Custom Cornea Rx: December 21, 2004

**OD:** Moria M2

**OS:** IntraLase

### Operative Summary

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<th>Procedure Type</th>
<th>Custom Myopia/Astig</th>
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<td>OD</td>
</tr>
<tr>
<td>Spherical Measurements</td>
<td>-1.56 (Wave) / -1.50 (Phor)</td>
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<tr>
<td>Cylinder Measurements</td>
<td>-2.67 (Wave) / -3.00 (Phor)</td>
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<tr>
<td>Axis Measurements</td>
<td>1.7 (Wave) / 177.0 (Phor)</td>
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<tr>
<td>Vertex Distance</td>
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<td>96</td>
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### Notes
- None

### Operative Summary

<table>
<thead>
<tr>
<th>Procedure Type</th>
<th>Custom Myopia/Astig</th>
</tr>
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<tbody>
<tr>
<td>Treatment Eye</td>
<td>OS</td>
</tr>
<tr>
<td>Spherical Measurements</td>
<td>-1.79 (Wave) / -2.25 (Phor)</td>
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<tr>
<td>Cylinder Measurements</td>
<td>-2.11 (Wave) / -2.50 (Phor)</td>
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<tr>
<td>Axis Measurements</td>
<td>1.2 (Wave) / 177.0 (Phor)</td>
</tr>
<tr>
<td>Vertex Distance</td>
<td>12.50 mm</td>
</tr>
<tr>
<td>Zernike Match</td>
<td>92%</td>
</tr>
<tr>
<td>Wavefront Defocus (D)</td>
<td>2.84</td>
</tr>
<tr>
<td>Offset (D)</td>
<td>+0.17</td>
</tr>
<tr>
<td>Pachy</td>
<td>OS</td>
</tr>
<tr>
<td></td>
<td>OD</td>
</tr>
<tr>
<td></td>
<td>OS</td>
</tr>
<tr>
<td></td>
<td>554</td>
</tr>
<tr>
<td></td>
<td>537</td>
</tr>
<tr>
<td></td>
<td>-458</td>
</tr>
<tr>
<td></td>
<td>-425</td>
</tr>
<tr>
<td></td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>112</td>
</tr>
</tbody>
</table>

### Notes
- None
Patient #1 – KR - 3 Months Post Laser

Refraction from Wavefront

| Sphere | 0.43 Diopters |
| Cylinder | -0.24 Diopters |
| Axis | 168 Degrees |
| Match | 22% |
| Diameter | 6.50mm |

Aberrations

| Defocus | 0.48 |
| Astigmatism | 0.13 |
| Coma | 0.51 |
| Spherical Aberration | 0.09 |
| Other | 0.33 |

Total Aberrations

0.62

High Order Aberrations

0.24

Moria M2 - 20/15

+0.43 -0.24 x168

IntraLase – 20/15

+0.06 -0.10 x119
Patient #1 – KR – 1 Year Post Laser

Refractive Cylinder Wavefront

<table>
<thead>
<tr>
<th></th>
<th>Sphere</th>
<th>Cylinder</th>
<th>Axis</th>
<th>Match</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.40 D</td>
<td>-0.70 D</td>
<td>9 D</td>
<td>36%</td>
<td>6.50mm</td>
</tr>
</tbody>
</table>

Aberrations

<table>
<thead>
<tr>
<th></th>
<th>Defocus</th>
<th>Astigmatism</th>
<th>Coma</th>
<th>Spherical Aberration</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.09</td>
<td>0.56</td>
<td>0.42</td>
<td>0.05</td>
<td>0.23</td>
</tr>
</tbody>
</table>

RMS (microns)

|                  | 0.48    | 0.27        |

Spherical Aberration

+0.40 -0.70 x 09

Moria M2 - 20/15

+0.24 -0.41 x 168

IntraLase – 20/15
Patient #2 – ED
Custom Cornea Rx: April 21, 2005

- **OD**: IntraLase
- **OS**: Moria M2

### OD
- **IntraLase**: 514
- **Moria M2**: 108
- **Residual Thickness**: -406
- **Nomogram/Offset**: -265

### OS
- **Moria M2**: 492
- **Residual Thickness**: -410
- **Nomogram/Offset**: -295

### Pachy
- **OD**: 98.3 microns
- **OS**: 107.9 microns

### Refraction
- Phoropter - spectacle plane
  - Pre-adjustment: -5.75 / -0.49 x 2 (SE = -6.00)
  - Net Offset: SE = 0.00
  - Post Adjustment: -5.75 / -0.49 x 2 (SE = -6.00)
- Wavefront-based - corneal plane
  - Pre-adjustment: -5.21 / -1.25 x 178 (SE = -5.85)
  - Net Offset: SE = 0.00
  - Post Adjustment: -5.21 / -1.25 x 178 (SE = -5.85)

### Nomogram/Offset
- Description: <Description>
- SE Nomogram Specification: Adjusted = Desired x 1.00 + 0.00
Patient #2 – ED - 1 Month Post Laser

**IntraLase**

- Sphere: 0.04 Diopters
- Cylinder: -0.38 Diopters
- Axis: 82 Degrees
- Match: 53%
- Diameter: 6.60mm

- Refraction from Wavefront: +0.04 -0.38 x 82
- High Order Aberrations: 0.47

- MR: -0.50 x 80 (20/15-)

**Moria M2**

- Sphere: 1.50 Diopters
- Cylinder: -1.19 Diopters
- Axis: 90 Degrees
- Match: 24%
- Diameter: 6.50mm

- Refraction from Wavefront: +1.50 -1.19 x 90
- High Order Aberrations: 1.04

- MR: +1.00 -1.25 x 74 (20/20)
Patient #2 – ED - 7 Months Post Laser

**IntraLase** – 20/20+
MR: pl -0.50 x106 (20/15-)

**Moria M2** – (20/25+)
MR: +0.50 -1.00 x 95 (20/15-)

+0.20 -0.32 x 86

+1.46 -1.18 x 95
Patient #2 – ED – 1 Year Post Laser IntraLase – 20/20+
MR: plano (20/20+)

IntraLase – 20/20+
MR: plano (20/20+)

Moria M2 – (20/20-2)
MR: +0.50 -0.50 x 85 (20/20)
Conclusions

Horizontal Corneal Incisions (Flaps) Biomechanically Induce Aberrations!

Total Aberrations

Shift Toward Hyperopia

Higher Order Aberrations

Mostly Spherical Aberration

Improving Flap Anatomy (planar) Reduces Induction of these Aberrations
Flap Creation Options:

Planar Flap

OD: IntraLase 90 um

Meniscus Flap

OS: Moria M2 90 um

Peripheral Steepening = Spherical Aberration

0 to 1.0 D

~2.0 D
Thank You!