Wavefront Analysis of Flap & Laser-induced aberrations in 2-step LASIK

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PURPOSE

• To identify aberrations created in a 2-step LASIK procedure
  – Step 1: making the LASIK flap with no laser treatment
  – Step 2: 1m later lifting the flap & treating the refractive error with a flying spot laser.
Methods

• Prospective randomized case series
• 11 patients, 22 eyes, scheduled for myopic LASIK
• Range: -1.00D to -9.25D sphere with < 2.75D of astigmatism
• 5 males and 6 females
• Mean age 43.7 years old
Methods

Measurements: UCVA, MR, BCVA & WF

Schedule: Surgical Treatment:

- 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
Methods

• **Microkeratomes:** Moria M2 & SKBM

• 22 eyes

  mean flap thickness

  - 10 eyes **SKBM:** nasal flap 169 ± 27 um
  - 12 eyes **Moria M2:**
    - 6 eyes nasal flap
    - 6 eyes superior flap
      - Randomly selected

  - 12 eyes **Moria M2:**

  - 6 eyes nasal flap
  - 6 eyes superior flap
    - Randomly selected
Methods

• Laser Excimer ablation was performed on all eyes with the LADARVision 4000 and based on the one month post flap manifest and cycloplegic refraction.

• Wave front analysis was performed on the LadarWave aberrometer. Analysis was performed using a 6.0mm pupil size.

• Statistical analysis: preformed on repeated measures of the variance in the change from pre-op adjusted with Bonferroni correction. (p<0.0125)
RESULTS

- Trend towards a slight hyperopic shift was noted in both sphere of the MR and WF refraction with Moria M2
- No significant associations between hinge placement and horizontal and vertical coma
- At 1 week post flap the RMS value of total HOA and other terms showed a statistically significant increase. At 1 month SA also showed a statistically significant increase from pre-op.
- Changes in HOA from pre-op increased post-laser at 1w and 3m in Total HOA and SA
Hyperopic Change Induced by Flap Creation and Laser

Hyperopic change in manifest sphere from pre-op

- Pre-op
- 1 week post flap
- 1 month post flap
- 1 week post laser
- 3 month post laser
# Flap Induced Hyperopia (Manifest Refraction)

<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>1 2</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>1 0</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>
</tr>
</tbody>
</table>

**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>1 2</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>
</tr>
<tr>
<td>SKBM</td>
<td>1 0</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>
</tr>
</tbody>
</table>

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

• Trend towards a slight hyperopic shift was noted in both sphere of the MR and WF refraction with Moria M2

• No significant associations between hinge placement and horizontal and vertical coma

• At 1 week post flap the RMS value of total HOA and other terms showed a statistically significant increase. At 1 month SA also showed a statistically significant increase from pre-op.

• Changes in HOA from pre-op increased post-laser at 1w and 3m in Total HOA and SA
Hinge position and Coma

- **Vertical Coma: pre-op**
  - To 1 day post-flap (p=0.98)
  - To 1 wk post-flap (p=0.66)
  - To 1 mo post-flap (p=0.79)

- **Horizontal Coma: pre-op**
  - To 1 day post-flap (p=0.97)
  - To 1 wk post-flap (p=0.63)
  - To 1 mo post-flap (p=0.33)
RESULTS

• Trend towards a slight hyperopic shift was noted in both sphere of the MR and WF refraction with Moria M2

• No significant associations between hinge placement and horizontal and vertical coma

• At 1 week post flap the RMS value of total HOA and other terms showed a statistically significant increase. At 1 month SA also showed a statistically significant increase from pre-op to post flap creation.

• Changes in HOA from pre-op increased post-laser at 1w and 3m in Total HOA and SA
Change in Total Higher Order Aberrations over time.

- Red: Pre op
- Blue: 1 day post flap
- Yellow: 1 week post flap
- Cyan: 1 month post flap
- Green: 1 week post laser
- Orange: 3 month post laser
## Flap Induced Aberrations

<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>0.09</td>
<td>0.01</td>
<td><strong>0.010</strong></td>
</tr>
<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>0.033</td>
</tr>
<tr>
<td>Other terms</td>
<td>22</td>
<td>0.05</td>
<td>0.01</td>
<td><strong>0.005</strong></td>
</tr>
</tbody>
</table>

### 1 wk

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

<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>0.08</td>
<td>0.02</td>
<td><strong>0.004</strong></td>
</tr>
<tr>
<td>Vertical Coma</td>
<td>22</td>
<td>-0.01</td>
<td>0.02</td>
<td>0.79</td>
</tr>
<tr>
<td>Horizontal Coma</td>
<td>22</td>
<td>0.03</td>
<td>0.02</td>
<td>0.27</td>
</tr>
<tr>
<td>Sph. Aberration</td>
<td>22</td>
<td>0.07</td>
<td>0.02</td>
<td><strong>0.008</strong></td>
</tr>
<tr>
<td>Other terms</td>
<td>22</td>
<td>0.05</td>
<td>0.01</td>
<td><strong>0.004</strong></td>
</tr>
</tbody>
</table>

### 1 mo

Table 4: Changes in higher order aberrations from pre-op to 1 month post-flap
RESULTS

• Trend towards a slight hyperopic shift was noted in both sphere of the MR and WF refraction with Moria M2
• No significant associations between hinge placement and horizontal and vertical coma
• At 1 week post flap the RMS value of total HOA and other terms showed a statistically significant increase. At 1 month SA also showed a statistically significant increase from pre-op.
• Changes in HOA from pre-op increased post-laser at 1w in total HOA, SA & other terms and 3m total HOA & SA.
## Flap to Laser Change in Aberrations

<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>0.41</td>
<td>0.10</td>
<td><strong>0.002</strong></td>
</tr>
<tr>
<td>Vertical Coma</td>
<td>22</td>
<td>0.16</td>
<td>0.05</td>
<td><strong>0.013</strong></td>
</tr>
<tr>
<td>Horizontal Coma</td>
<td>22</td>
<td>0.11</td>
<td>0.03</td>
<td>0.10</td>
</tr>
<tr>
<td>Sph. Aberration</td>
<td>22</td>
<td>0.38</td>
<td>0.09</td>
<td><strong>0.002</strong></td>
</tr>
<tr>
<td>Other terms</td>
<td>22</td>
<td>0.08</td>
<td>0.02</td>
<td><strong>0.009</strong></td>
</tr>
</tbody>
</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><strong>0.004</strong></td>
</tr>
<tr>
<td>Vertical Coma</td>
<td>22</td>
<td>0.17</td>
<td>0.07</td>
<td>0.027</td>
</tr>
<tr>
<td>Horizontal Coma</td>
<td>22</td>
<td>0.08</td>
<td>0.03</td>
<td><strong>0.048</strong></td>
</tr>
<tr>
<td>Sph. Aberration</td>
<td>22</td>
<td>0.31</td>
<td>0.08</td>
<td><strong>0.005</strong></td>
</tr>
<tr>
<td>Other terms</td>
<td>22</td>
<td>0.03</td>
<td>0.03</td>
<td>0.31</td>
</tr>
</tbody>
</table>

**Table 6:** Changes in higher order aberrations from pre-op to 3 month post-laser
Flap Striae Induced Coma
OS Moria Nasal Hinge

1 week striae  repositioned flap
## Flap Striae Induced Coma

**OS Moria Nasal (180)**

<table>
<thead>
<tr>
<th></th>
<th>Coma</th>
<th>Axis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-op</strong></td>
<td>0.49</td>
<td>135°</td>
</tr>
<tr>
<td><strong>1W post flap</strong></td>
<td>0.43</td>
<td>220°</td>
</tr>
<tr>
<td><strong>1 W post lift</strong></td>
<td>0.21</td>
<td>135°</td>
</tr>
</tbody>
</table>

- Flap Striae inferonasally at ~220°
Discussion

• Limitations
  – Sample size was small for analysis of microkeratome results separately (10 and 12 eyes in each group)
  – The two microkeratomes had different targeted flap thickness of 130_m (MoriaM2) and 160_m (SKBM)
Conclusion

- Lasik flap creation induces changes in LOA and HOA ocular aberrations.
- The change in LOA is microkeratome dependent, with the MoriaM2 inducing a predictable hyperopic shift of +0.50D.
**Conclusion**

- HOA increase to a much larger degree post laser than post flap making a two-step procedure unnecessary in conventional LASIK.
- Further investigation of flap-induced aberrations relative to those induced following customized ablation will be required in the future.
Thank You For Your Attention!