Corneal Wavefront-guided laser vision correction with EPI-LASIK

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Laser vision correction

Most patients have low order aberrations
10-15% have significant higher-order aberration

Correction of low order aberrations with excimer laser induce corneal aberrations.
Reasonable reductions in HOAs after wavefront-guided Laser vision correction have been reported.

2008. Stonecipher KG, Padmanabhan P
Only LOA correction

LOA & HOA correction

Only HOA correction
Keratron Scout simulation

Only LOA correction

LOA & HOA correction

Only HOA correction
Keratron Scout simulation

Pre-op:
VA 20/200
R : -6.25Ds=-2.00Dc Ax 2

CW-guided

EpiLASIK, Post-op 1yrs.
VA 20/20
R : +0.50Ds=-0.75Dc Ax 77
Epi- LASIK

✓ Marriage of Surface ablation and LASIK

✓ In previous studies, LASIK would bring more higher-order aberrations because of the formation of the stromal flap. As surface procedures produce no stromal flap, they would theoretically induce fewer higher-order aberrations.

✓ Various changes of higher-order aberration would happen at smaller and larger pupil sizes after Epi-LASIK, and that visual performance may be better in the Epi-LASIK group than in the LASIK group for a larger pupil.


Wavefront customised treatment

✓ Corneal wavefront treatments have the advantage of being independent of accommodation effects or light/pupil conditions.

✓ Ocular wavefront treatments is based on objective refraction of the complete human eye system.

✓ Aspherical treatments have the advantage of saving tissue, time and a due to their simplicity they offer a better predictability.
Study Aim

To evaluate the outcome of corneal wavefront-guided Epi-LASIK for the treatment of myopia and myopic astigmatism:
Scout wavefront analyser + Amaris 750S
A single center, nonrandomized, comparative study
Seoul St. Mary’s Hospital, between May 2013~June 2014
124 eyes, 62 patients

Inclusion criteria
- Minimum age of 20 years
- Myopia or Myopic astigmatism
- Minimum calculated residual corneal stromal bed thickness, 300 μm

Exclusion criteria
- Other ophthalmic pathology except for refractive error
- Unstable refraction within 6 months
Ablations calculation

✓ ORK-CAM software module.
Surgical procedure

✓ For selecting the type of correction to be applied (Aberration-Free, Corneal Wavefront Guided or Ocular Wavefront Guided), the Decision-Tree was applied.

✓ Wavefront-guided surface ablation using the AMARIS

Scout wavefront analyser SCHWIND
SCHWIND AMARIS 750S Excimer Laser
Epikeratome : Moria Epi-K
## Decision Tree analysis system

<table>
<thead>
<tr>
<th>Level of aberration</th>
<th>Aspheric aberration neutral</th>
<th>CW-guided</th>
<th>OW-guided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corneal AND Ocular Wavefronts $&lt; 0.25$ DEq</td>
<td>Always</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Corneal OR Ocular Wavefront between $0.25$ DEq and $0.50$ DEq</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corneal AND Ocular Wavefronts $&gt; 0.50$ DEq</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total 124 eyes

- **Corneal WF**: 56%
- **Ocular WF**: 32%
- **Aberration Free**: 12%

**Total 124 eyes**
Results: Patients

- Number of eyes pre OP: 69
- Average age@surgery: 27.31 years (range 20 to 38)
- Gender female: 54.5% or 24 eyes male: 26.5% or 20 eyes female
- Eye left: 50.0% or 22 eyes/ right: 50.0% or 22 eyes

- Pre SR equiv: mean -5.32 D ± 1.27 D
- Pre SR sph: mean -4.28 D ± 1.53 D
- Pre SR cyl: mean -1.01 D ± 0.54 D
Results: Distribution of UCVA

- ≥20/20:
  - 1wek: 37%
  - 1mo: 69%
  - 2mo: 65%
  - 6mo: 80%
  - 12mo: 94%

- ≥20/25:
  - 1wek: 76%
  - 1mo: 65%
  - 2mo: 80%
  - 6mo: 87%
  - 12mo: 91%

- ≥20/40:
  - 1wek: 91%
  - 1mo: 93%
  - 2mo: 98%
  - 6mo: 98%
  - 12mo: 100%

- ≥20/80:
  - 1wek: 0,95
  - 1mo: 0,95
  - 2mo: 0,97
  - 6mo: 1
  - 12mo: 1
Results: Distribution of BCVA

- ≥20/25: 
  - 1w: 70%
  - 1m: 96%
  - 2m: 98%
  - 6m: 100%
  - 1y: 100%

- ≥20/20: 
  - 1w: 48%
  - 1m: 96%
  - 2m: 98%
  - 6m: 100%
  - 1y: 100%

- ≥20/15: 
  - 1w: 29%
  - 1m: 95%
  - 2m: 96%
  - 6m: 98%
  - 1y: 100%

Bars represent the percentage of patients achieving visual acuity as indicated.
Results: Refractive outcome

<table>
<thead>
<tr>
<th></th>
<th>Pre OP</th>
<th>1 week</th>
<th>1mo</th>
<th>2mo</th>
<th>6mo</th>
<th>12mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spherical</td>
<td>-4.28</td>
<td>-0.25</td>
<td>-0.18</td>
<td>-0.15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cylinder</td>
<td>-1.01</td>
<td>-0.42</td>
<td>-0.33</td>
<td>-0.32</td>
<td>-0.21</td>
<td>-0.21</td>
</tr>
<tr>
<td>Total SE</td>
<td>-5.32</td>
<td>-0.56</td>
<td>-0.34</td>
<td>-0.33</td>
<td>-0.12</td>
<td>-0.13</td>
</tr>
</tbody>
</table>

Percentage within Attempted

- ≤±0.50D: 95% (2mo), 96% (6mo), 97% (12mo)
- ≤±1.00D: 96% (2mo), 98% (6mo), 100% (12mo)
- ≤±1.50D: 100%

95% within +/- 0.5D
Results: Cornea HOA

Corneal aberrations increased significantly after treatment.

* Significant (p < .05) compared with preoperative baseline within group
There was no significant difference between two groups.

**Results:**

Contrast sensitivity

Contrast sensitivity over time with different cycle/degree settings:

- Pre Op
- 1 wk
- 2 mo.
- 6 mo.
- 12 mo.

* Significant (p < .05) compared with preoperative baseline within group.
Clinical Results of eye tracking system

Preoperative anterior segment photo
pupil centroid shift: +0.2mm / +0.1 mm
(X / Y axis)

During operation
pupil centroid shift
(X / Y axis) - ORK CAM
Eye tracking system in Amaris

✓ Static: Rotation between sitting and supine position

✓ Dynamic: Wiggling of eye while fixating a target (usually increased in supine position)
Clinical Results of eye tracking system

66 Eyes of Epi- LASIK patients Using Amaris

<table>
<thead>
<tr>
<th>Static Eye tracking</th>
<th>Success</th>
<th>Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCC</td>
<td>100 %</td>
<td>0 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dynamic Eye tracking</th>
<th>Success</th>
<th>Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCC</td>
<td>86.9 %</td>
<td>13.0 %</td>
</tr>
<tr>
<td>Rolling</td>
<td>86.9 %</td>
<td>13.0 %</td>
</tr>
<tr>
<td>X</td>
<td>86.9 %</td>
<td>13.0 %</td>
</tr>
<tr>
<td>Y</td>
<td>86.9 %</td>
<td>13.0 %</td>
</tr>
<tr>
<td>Z</td>
<td>86.9 %</td>
<td>13.0 %</td>
</tr>
</tbody>
</table>
Clinical results comparison of Amaris 750S/Visx S4 Efficacy of Eye-tracking procedure

- There was no significant difference between two groups:
  - Post OP. 1wk: -0,78 vs -0,62
  - Post OP. 2mo: -0,33 vs -0,55
  - Post OP. 6mo: -0,12 vs -0,58
  - Post OP. 12mo: -0,1 vs -0,58

Spherical Equivalents (Diopter)
Amaris 750S/Visx S4 Efficacy of Eye-tracking procedure according to cylinder amounts in the three groups

Group 1: Cylinder > 1.00D
Group 2: Cylinder 0.75D~1D
Group 3: Cylinder ≤ 0.50D
Efficacy of Eye-tracking procedure according to cylinder amounts in the three groups

- **Group 1**: Cylinder > 1.00D
- **Group 2**: Cylinder 0.75~1D
- **Group 3**: Cylinder < 0.50D

- Amaris 750S/Visx is significantly effective in cylinder correction, especially over 1D.
- Preoperative cylinder of 0.50D or less was overcorrected both Amaris 750S and Visx S4
Conclusions

The clinical outcomes of Cornea wavefront-guided surface ablation using the AMARIS 750S showed stable results in SE, astigmatism.

- High predictability
- Improved or remained contrast sensitivity
- Iris registration may play an important role in cylinder correction in surface ablation

- Slightly increased High order aberration
  (But previous our studies demonstrated AMARIS 750S induced less aberrations than Visx S4)
Other story
Optical system

Monocular sight
- single eyepiece
- single objective lens

Biocular sight
- two eyepieces
- one objective lens

Binocular sight
- two eyepieces
- two objective lenses
I am AMARIS user. I felt difficulty to insert Raindrop inlay.

Binocular optical system, Each eye has a totally independent channel. The left and right eyes receive different perspective views of the same object. → stereopsis creation

There is no problem to see 2dimensional object. But It is problem to align different plane object, like raindrop inlay along the pupil.
CONCORDANCE BETWEEN AIMING AND TRACKING LASER ON LEFT SCOPE

Lt.scope in AMARIS

Rt.scope in AMARIS

Aiming laser (fixed)

Tracking laser (pupillary center)
CONCORDANCE BETWEEN AIMING AND TRACKING LASER ON LEFT SCOPE

Lt.scope in AMARIS

Rt.scope in AMARIS
Stereoacuity and depth perception decreases as magnification increases when viewing with microscope.

*Du LT et al. Binocul Vis Strabismus Q 2001;16;61-7*
Focus on left scope
(Lt. eye dominance or Close Rt. eye)
After opening right eye
You can see different image.
Raindrop
: Accordance with

**Left scope**

- Deviation toward temporal side in Lt. eye
- Deviation toward nasal side in Rt. eye

**Right scope**

- Deviation toward temporal side in Rt. eye
- Deviation toward nasal side in Lt. eye
Where will you drop it?

After fusing 2 images from each scope, finding accurate location of pupillary center is ideal.

If Raindrop is placed on pupillary center, the distances between Raindrop and tracking laser would be equal in both scopes.

Pupillary center moves toward nasal side as pupil constricts. Therefore, using the contralateral ocular scope to the implanted eye could be an alternative.

Confirmation of placement via slitlamp is necessary. Especially, examination with low magnification is recommended.
In Epi-LASIK, cornea WF guided ablation profiles and eye tracking have presumably led to better refractive outcomes.

Increased High order aberrations after Amaris 750S laser system were not related to the most significant visual loss.

We are cautious in astigmatic correction for eyes with myopia and manifest cylinder of ≤ 0.50 D

Surgeon should become more aware of the centering issues like the corneal inlay implantation along the pupil
Thank you for your attention!!

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Wavefront guided customization
Goals

✓ Spherocylinder correction

✓ To correct the aberration that are induced by conventional laser vision correction and pre-existing aberration.
Results: Cornea HOA

Corneal aberrations increased significantly after treatment

* Significant (p < .05) compared with preoperative baseline within group
Found concentration in AMARIS
Focusing on left scope

Image on Lt.scope
After opening right eye
Moving Raindrop toward right side
Moving Raindrop to the center

Image on Lt.scope

Image on Rt.scope
Finding pupillary center: Accordance with

**Left scope**
- Displacement toward temporal side in Rt. eye
- Displacement toward nasal side in Lt. eye

**Right scope**
- Displacement toward temporal side in Lt. eye
- Displacement toward nasal side in Rt. eye
Our questions

✓ Fusion of 2 image from each eyepiece (scope) to find accurate location of pupillary center in case of inlay implantation

✓ The problem of eye-dominance