



Aberrations Caused by Decentration in Customized Laser Refractive Surgery



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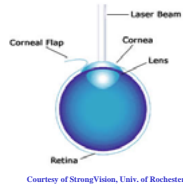
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INTRODUCTION

For many years, glasses and contact lenses have been used to correct large errors in the optical quality of the eye, namely defocus and astigmatism. Laser refractive surgery, in particular laser in-situ keratomileusis (LASIK), has emerged as another method that can successfully be used to correct for the eye's basic refractive errors.



Courtesy of StrongVision, Univ. of Rochester

Conventional laser refractive surgery procedures correct defocus and astigmatism but typically induce higher order aberrations. These aberrations cause blurred images to be formed on the retina, especially when the pupil size is large (such as at night).

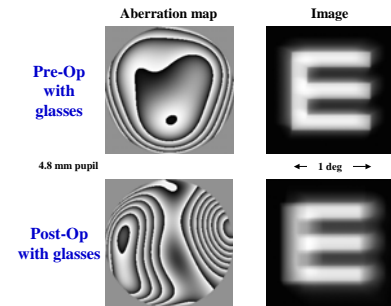
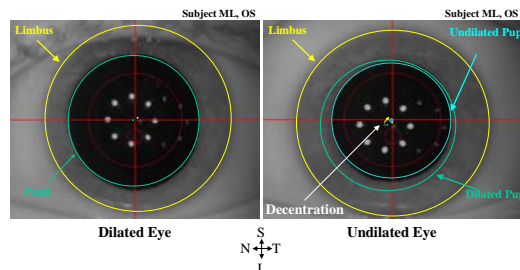
PROJECT GOALS

- Determine how much the center of the pupil physically shifts from a dilated to an undilated (natural) state.
- Determine what percentage of the overall amount of aberrations created after customized LASIK could theoretically be attributed to static shifts of the customized ablation treatment.
- Find ways to reduce higher order aberrations induced by decentrations in refractive surgery.

PROCEDURE

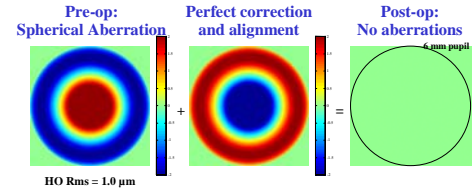
1. Captured images of the pupil and iris of 7 pre-LASIK subjects (13 eyes) when undilated and dilated with 2.5% neosynephrine.
2. Determined location of the pupil center relative to the limbus center for both conditions.
3. Decentration calculated as the shift in pupil center from a dilated to undilated pupil.
4. Shack-Hartmann wavefront sensor was used to measure the preoperative wave aberration over the dilated pupil for each eye.
5. Calculated aberrations induced solely due to a shift in the location of the center of the pupil in a customized LASIK procedure.
6. Measured average 6-month postoperative dilated wave aberration for each eye.

Decentration of ablation due to shift in pupil center location

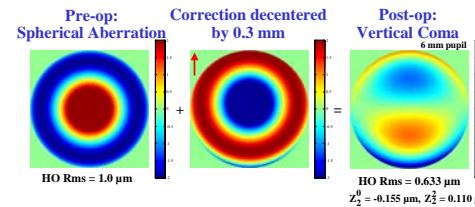


Several techniques are being developed to correct for higher order aberrations in the eye, including customized LASIK (or wavefront-guided LASIK). A fundamental limitation on the quality of vision correction with refractive surgery is decentration. Decentrations can be caused by shifts in the center of the pupil when aberrations are measured over the dilated pupil preoperatively and when they are corrected surgically over an undilated pupil. Any shift that is unaccounted for in the location of the pupil center between these two pupil conditions will result in a decentration of the customized ablation profile and the generation of undesired aberrations in the eye.

Perfect centration of customized ablation

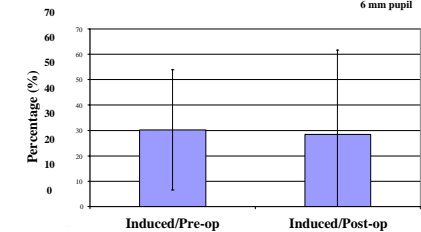


Aberrations induced by decentration



Aberrations theoretically induced due to decentration of ablation

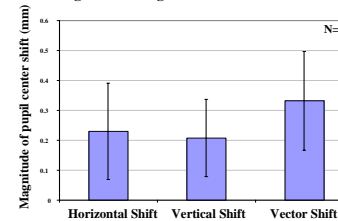
Range of % of post-op higher order rms: 5 to 130.3%
Average % of post-op higher order rms: 29 ± 33.2%



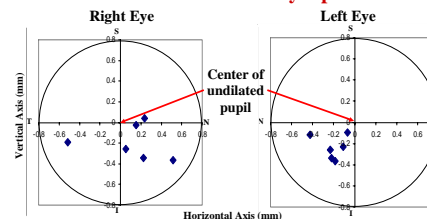
RESULTS

Magnitudes of pupil center shift

Range of vector magnitudes: 0.08 mm to 0.63 mm
Average vector magnitude: 0.33 mm ± 0.165 mm



Pupil center shifts in inferior-nasal direction when dilated with neosynephrine



Ablation is decentered in the superior-temporal direction.

CONCLUSIONS

1. The average magnitude of the shift in pupil center location from a neosynephrine dilated to undilated condition for 13 eyes was 0.33 mm ± 0.165 mm. (Range of 0.08 to 0.63 mm)
2. As the pupil dilated, the pupil center tended to shift in the inferior-nasal direction.
3. Decentrations of a customized ablation induce aberrations after surgery.
4. The average percentage of postoperative higher order aberrations that could be theoretically accounted for by decentrations is 29 ± 33.2%.
5. A potential solution to reduce aberrations generated by decentrations is to reference the customized ablation with respect to the limbus or iris and NOT the center of the pupil.

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