LASIK 近視手術病人四十歲後的視覺品質

＝＝資深手術醫師的觀點

丘子宏
LASIK 手術後的視覺

- **Visual acuity**: The measurement of high contrast Snellen acuity but not other functions under different condition
- **Quality of vision**: measure the visual functions in variable condition in the daily life
- Patients may complain of visual problem in spite of good Snellen VA
- Ageing can worsen the adverse symptoms
Common visual problems in older LASIK patients

- Blurring of far vision
- Poor vision at night
- Reading difficulty
- Visual symptoms including glare halo starburst
- Dry eye
Basic Causes

- Residual refractive error
- Presbyopia
- Dry eye
- Nuclear sclerosis of lens
Residual refractive error

- Primary under-correction
- Regression
- Strong predictor of patient satisfaction
  (Schmidt Arch Ophth 2007)
- Strong relation with night visual symptoms
Primary under-correction

- Noncorneal causes
  - Inaccurate refraction
  - Inadequate laser energy
- Corneal causes
  - Biomechanical stability
  - Epithelial change
Regression

- Epithelial thickening
- Greater amount of correction
- Small optical zone
Long-term Follow-up Myopic LASIK

Zalentein et al. JRS 2009
Long-term Follow-up  Myopic LASIK

Zalentein et al  JRS 2009
Ten-year follow-up of LASIK for myopia up to -10 diopters
Alio AJO 2008
Effect of regression

- Poor distant vision
- Halo and glare at night
- Delay onset of presbyopia-----advantage
Presbyopia

- Great frustration in a happy LASIK patients
Duane's study of subjective accommodation and age demonstrates the linearity in accommodative decline (From the Normal Values of the Accommodation at all ages; Alexander Duane, Journal of the AMA, 1912).
Amplitude of accommodation
Near point

![Graph showing the relationship between near point and age](image)

- Near point at 5 cm
- Near point at 10 cm
- Near point at reading distance
- Near point at arm's length
- Near point at 4 m

**Presbyopia**
LASIK for presbyopia patients

PresbyLasik

- Multifocal ablation on cornea
  - Center-distance
  - Center-near
- Mechanism: increase spherical aberration to increase depth-of-focus

Monovision LASIK
Evidence for Delayed Presbyopia after Photorefractive Keratectomy for Myopia (10 years result)

Artola A  Ophthalmology  2006
Evidence for Delayed Presbyopia after Photorefractive Keratectomy for Myopia (10 years result)

Artola A Ophthalmology 2006
Dry eye in LASIK patients

- Immediate post-LASIK (within one year)
- Long-term after LASIK (after many years)
Causes of dry eye after LASIK

- Neurotropic tear film instability
- Reduced blink rate
- Altered lid-corneal contact
- Post-op medication
- Alteration in accommodation and convergence following LASIK
# Prevalence of Postoperative Dry Eye

<table>
<thead>
<tr>
<th>Surgery</th>
<th>Study</th>
<th>N</th>
<th>Prevalence (%)</th>
<th>Follow-up Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LASIK</strong></td>
<td>Shoja 2007</td>
<td>190</td>
<td>50</td>
<td>1 week</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20</td>
<td>≥6 months</td>
</tr>
<tr>
<td></td>
<td>DePaiva 2006</td>
<td>35</td>
<td>0</td>
<td>1 week</td>
</tr>
<tr>
<td></td>
<td>Albietz 2002</td>
<td>450</td>
<td>38</td>
<td>2 weeks, myopia</td>
</tr>
<tr>
<td></td>
<td>Albietz 2002</td>
<td>88</td>
<td>32</td>
<td>Chronic, hyperopia</td>
</tr>
<tr>
<td></td>
<td>Hovanesian 2001</td>
<td>587</td>
<td>45</td>
<td>≥6 months</td>
</tr>
<tr>
<td></td>
<td>Yu 2000</td>
<td>58</td>
<td>16</td>
<td>1 week</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>59</td>
<td>1 month</td>
</tr>
<tr>
<td><strong>PRK</strong></td>
<td>Hovanesian 2001</td>
<td>241</td>
<td>41</td>
<td>≥6 months</td>
</tr>
<tr>
<td><strong>Cataract</strong></td>
<td>Roberts 2007</td>
<td>15</td>
<td>27-60&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1 month</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>47-87&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Li 2007 (staining)</td>
<td>37</td>
<td>11</td>
<td>1 week</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>16</td>
<td>1 month</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>16</td>
<td>3 months</td>
</tr>
</tbody>
</table>

<sup>a</sup> Prevalence of various dry eye dys functions.

Dry eyes become more severe many years after LASIK may be resulted from ageing rather than LASIK itself.
Dry eye cascade
Causes and contributing factors of abnormal tear film
# Table 1. Risk Factors for Dry Eye

<table>
<thead>
<tr>
<th>Mostly consistent</th>
<th>Suggestive</th>
<th>Unclear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Older age</td>
<td>Asian race</td>
<td>Cigarette smoking</td>
</tr>
<tr>
<td>Female sex</td>
<td>Medications</td>
<td>Hispanic ethnicity</td>
</tr>
<tr>
<td>Postmenopausal estrogen therapy</td>
<td>Tricyclic antidepressants</td>
<td>Anticholinergics</td>
</tr>
<tr>
<td>Omega-3 and Omega-6 fatty acids</td>
<td>Selective serotonin reuptake inhibitors</td>
<td>Anxiolytics</td>
</tr>
<tr>
<td>Medications</td>
<td>Diuretics</td>
<td>Antipsychotics</td>
</tr>
<tr>
<td>Antihistamines</td>
<td>Beta-blockers</td>
<td>Alcohol</td>
</tr>
<tr>
<td>Connective tissue disease</td>
<td>Diabetes mellitus</td>
<td>Menopause</td>
</tr>
<tr>
<td>LASIK and refractive excimer laser surgery</td>
<td>HIV/HTLV1 infection</td>
<td>Botulinum toxin injection</td>
</tr>
<tr>
<td>Radiation therapy</td>
<td>Systemic chemotherapy</td>
<td></td>
</tr>
<tr>
<td>Hematopoietic stem cell transplantation</td>
<td>Large incision ECCE and penetrating keratoplasty</td>
<td></td>
</tr>
<tr>
<td>Vitamin A deficiency</td>
<td>Isotretinoin</td>
<td></td>
</tr>
<tr>
<td>Hepatitis C infection</td>
<td>Low humidity environments</td>
<td></td>
</tr>
<tr>
<td>Androgen deficiency</td>
<td>Sarcoidosis</td>
<td>Acne</td>
</tr>
<tr>
<td></td>
<td>Ovarian dysfunction</td>
<td>Gout</td>
</tr>
</tbody>
</table>

Prevalence of dry eye symptoms by age in the Beaver Dam study
CVS and LASIK

- 40% LASIK patient have significant VDT exposure
- 10% LASIK patients have documented CVS
- Factors:
  - Dryness due to decrease blinking
  - Change in relative accommodation
  - Change in vergence function
Quality of Vision

- Visual acuity (distance and near)
- Glare
- Haze
- Halos, rings, starburst
- Clarity
- Fluctuation of VA
- Double vision, ghost image
Decrease of visual quality

- Mainly due to increase of HOA (spherical aberration) and decrease of contrast sensitivity
- Decrease visual quality in older LASIK patients mostly are the result of aging change rather than the LASIK
Optical quality evaluation for LASIK and ageing eyes

- High-contrast Snellen acuity
- Wavefront analysis
- Contrast sensitivity test
Prolate normal cornea

$Q_{\text{avg}} = -0.26$

$Q_{\text{no SA}} = -0.52$

Prolate – “Predators”

Eagles, Man, ...
Oblate cornea after LASIK

J Holladay
Asphericity (Q-value)

The curvature of an ellipsoid — whether prolate or oblate — can be expressed through an asphericity quotient called the Q-value.

<table>
<thead>
<tr>
<th>Prolate ellipsoid</th>
<th>Severe keratoconus, +5 D PRK</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Q = -2$</td>
<td>Mild keratoconus, +2 D PRK</td>
</tr>
<tr>
<td>$Q = -1$</td>
<td>No spherical aberration</td>
</tr>
<tr>
<td>$Q = -0.52$</td>
<td>Normal</td>
</tr>
<tr>
<td>$Q = -0.26$</td>
<td></td>
</tr>
<tr>
<td>$Q = 0$</td>
<td>Spherical</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oblate ellipsoid</th>
<th>8-cut RK, -5 D PRK</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Q = +1$</td>
<td>16-cut RK, -12 D PRK</td>
</tr>
<tr>
<td>$Q = +2$</td>
<td></td>
</tr>
</tbody>
</table>

Source: Holladay JT
Nuclear sclerosis
Nuclear sclerosis

- Change of refractive index and error
- Change of spherical aberration
- Glare
- Night dimming
- Increase light scattering
- Monocular diplopia
- Color perception change
- Poor depth perceiving
- Decrease contrast sensitivity
Spherical aberration

- When spherical aberration reach the clinical awareness threshold (0.4u RMS), contrast sensitivity and MTF will decrease and induce night vision problems as blurring, halos, glare, and starburst
Factors induce spherical aberration of the eye

- Biologic factor: Curved surface of eyeball
- Optical factor: Correction of spherical error produce SA
- Ageing of the crystal lens: increase positive SA
As the crystalline lens ages, its positive spherical aberration increases. This causes an increase in total optical system aberration. Implanting a standard IOL with positive spherical aberration causes an even greater increase.
Spherical aberration
Small pupil reduce SA
SA increased with large pupil
Contrast Sensitivity

- Contrast sensitivity determines the lowest contrast level which can be detected by a patient for a given size target.
- Contrast sensitivity measures two variables, size and contrast, while acuity measures only size.
Contrast sensitivity after LASIK
Contrast sensitivity after LASIK
Photopic and Mesopic CS (pupil effect)
<table>
<thead>
<tr>
<th>AGE (YEARS)</th>
<th>PHOTOPIC PUPIL DIAMETER (MM)</th>
<th>SCOTOPIC PUPIL DIAMETER (MM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>5.0</td>
<td>8.0</td>
</tr>
<tr>
<td>40</td>
<td>4.0</td>
<td>6.0</td>
</tr>
<tr>
<td>50</td>
<td>3.5</td>
<td>5.5</td>
</tr>
<tr>
<td>60</td>
<td>3.0</td>
<td>4.25</td>
</tr>
<tr>
<td>70</td>
<td>2.5</td>
<td>3.0</td>
</tr>
</tbody>
</table>

* From Borish’s Clinical Refraction 2006
Contrast (low and high)
Conclusion

- LASIK patients older than 40 may become unhappy about their vision and some annoying symptoms
- Decrease of VA from regression is the most common problem
- Reading difficulty is the next common complaint
- Dry eyes due to aging is the same as general population
- Nuclear sclerosis may further enhance the decreased visual quality of LASIK by increase of HOA, especially spherical aberration, and decrease of contrast sensitivity
Thank you for your attention