How do you adjust for IOP in a LASIK patient?

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Principle of applanation tonometry

• Imbert Fick law

• Applanation force = IOP x Applanated area
  – For a corneal thickness of ~ 500 µm and applanation
    area of 3.06 mm, corneal elastic resistance is
    counterbalanced by surface tension from tear film
Assumptions

• All corneas have uniform thickness (~ 500 \(\mu m\) by optical pachymetry)
• The cornea is perfectly elastic and offers no resistance to applanation
• The cornea, limbus and sclera have homogeneous elasticity

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**Figure 1.** The possible mechanisms for the influence of cornea structural and material properties on IOP measurement by applanation tonometry. Corneal curvature dimensions were exaggerated for illustration.

Jun Liu, PhD, Cynthia J. Roberts, PhD
J Cataract Refract Surg 2005; 31:146-155
Corneal biomechanics and IOP

• Mathematical model constructed in which applanation measurement is dependent on true IOP and corneal biomechanical properties such as
  – thickness
  – curvature
  – elasticity
• Simulations performed by varying 1 parameter at a time keeping the other 2 constant

Corneal biomechanics and IOP

• Change in predicted IOP between upper and lower limits of these parameters in a normal population were calculated
• Corneal elasticity had the largest influence
  – Corneal thickness : 2.87mm Hg
  – Corneal curvature : 1.76 mm Hg
  – Young’s modulus : 17.26 mm Hg
The Cornea is Not a Piece of Plastic

Cynthia Roberts, PhD

Journal of Refractive Surgery Volume 16 July/August 2000

Decrease in IOP after LASIK

- Flap creation
- Corneal thinning
- Change in elasticity
How can we assess true IOP after LASIK?

- Database of 8113 eyes undergoing LASIK
- Pre-op and 3 month post-op GAT IOP measurements
  - Mean spherical equivalent change was 5.00 ± 2.6 D
  - Mean IOP decrease was 2.0 ± 3.3 mm Hg
- Linear regression analysis
  - 0.12 mm Hg decrease per diopter of correction
  - Decrease of 1.36 mm Hg independent of laser ablation and due to creation of LASIK flap.
A Correction Formula for the Real Intraocular Pressure After LASIK for the Correction of Myopic Astigmatism

Markus Kohlhaas, MD; Eberhard Spoerl, PhD; Andreas G. Boehm, MD; Katharina Pollack, MD

- 101 eyes of 59 patients
- Pre and 6 months post LASIK GAT measurements
- Mean 3.6 mm Hg reduction (0.4 mm Hg per diopter correction)
- IOP (real) = IOP (measured) + (540 – CCT) / 71 + (43 - K value) / 2.7 + 0.75 mm Hg

A Predictive Model for Postoperative Intraocular Pressure Among Patients Undergoing Laser in Situ Keratomileusis (LASIK)

Chia-Ching Yang, MD, I-Jong Wang, MD, Yue-Cune Chang, PhD, Luke Long-Kuang Lin, MD, and Tony Hsiu-Hsi Chen, PhD

- Both eyes of 193 subjects undergoing LASIK
- IOP measured pre and 1 week post-op with non-contact tonometer
Limitations of statistical models and correction formulae

- Assume there is no change in IOP post LASIK
- Variable results
- Usually incorporate only some of the known factors that affect IOP measurement

Alternative IOP measurement techniques

- Schiotz tonometer
- Pneumotonometry
-Tonopen
- Dynamic Contour Tonometry
- Ocular Response Analyzer
- Pressure phosphene tonometer
- Rebound tonometry
Ocular response analyzer

- Non contact dynamic tonometry
- Collimated air pulse to applanate cornea
- Initial applanation phase, beyond concavity and rebound through a second applanation.

ORA

- Parameters measured
  - Corneal hysteresis (CH)
  - Corneal resistance factor (CRF)
  - Goldmann correlated IOP - IOPg
  - Corneal compensated IOP - IOPcc
Dynamic contour tonometry (PASCAL)

- Non-applanation tonometer
- Concave tip used to ‘contour match’ a convex segment of the central cornea
- Minimal distortion of cornea allows all of the forces to be directed to a sensor in the center of the tip

DCT

- Dynamic recording of >100 measurements throughout the cardiac cycle
- Digitally displays average diastolic IOP
DCT

- Only tonometer that appears to be independent of corneal properties
- Calibrated using manometric measurements

Changes in Corneal Biomechanics and Intraocular Pressure Following LASIK Using Static, Dynamic, and Noncontact Tonometry

JAY S. PEPOSE, MD, PhD, SUSAN K. FEIGENBAUM, PhD, MUJTABA A. QAZI, MD, JEFFREY P. AM J OPHTHALMOL 2007;143:39–47OBERTS, PhD

- 66 eyes undergoing LASIK
- Pre and 1 week post operative IOP measurements
  - GAT, DCT, ORA (randomized order)
- Pre-op spherical equivalent -5.1 ± 2.8 D
### TABLE 2. Change in IOP Measurements After LASIK

<table>
<thead>
<tr>
<th>Change</th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>Postop-Prew</th>
<th>P for Two-tailed t Test of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>GAT IOP (mm Hg)</td>
<td>13.8 ± 3.3</td>
<td>12.0 ± 2.7</td>
<td>-1.8 ± 2.8</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>ORA-G IOP (mm Hg)</td>
<td>15.2 ± 3.4</td>
<td>10.6 ± 2.6</td>
<td>-4.6 ± 2.6</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>ORA-CC IOP (mm Hg)</td>
<td>15.4 ± 3.2</td>
<td>13.1 ± 2.0</td>
<td>-2.1 ± 2.6</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>PDCT IOP (mm Hg)</td>
<td>17.1 ± 3.3</td>
<td>16.5 ± 2.2</td>
<td>-0.5 ± 2.6</td>
<td>.27</td>
</tr>
<tr>
<td>CCT (μm)</td>
<td>550.7 ± 34.3</td>
<td>460.5 ± 48</td>
<td>-90.2 ± 43.7</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

### TABLE 4. Changes in Biomechanical Metrics After LASIK

<table>
<thead>
<tr>
<th>Metric</th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>Postoperative-Preoperative</th>
<th>Average % Change</th>
<th>P for Two-tailed t Test for Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corneal hysteresis</td>
<td>9.7 ± 1.8</td>
<td>8.0 ± 1.6</td>
<td>-1.7 ± 1.5</td>
<td>-16.2</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Corneal resistance factor</td>
<td>9.5 ± 1.9</td>
<td>6.7 ± 1.7</td>
<td>-2.8 ± 1.6</td>
<td>-28.6</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Ocular pulse amplitude</td>
<td>2.1 ± 0.7</td>
<td>2.0 ± 0.5</td>
<td>-0.1 ± 0.5</td>
<td>-1.8</td>
<td>.32 (NS)</td>
</tr>
</tbody>
</table>

LASIK = laser in situ keratomileusis; NS = not significant.
• Patients undergoing first-time LASIK
• Fellow eyes served as controls
• GAT and DCT measurements obtained OU pre and 2 weeks post LASIK
• Change in spherical equivalent -5.25 ± 2.8 D
Limitations of DCT

- Relatively long duration of measurement
- One study showed that it is affected by corneal curvature
  - Francis et al, LALES – Ophthalmology Jan 2007
  - No refractive surgery
  - DCT higher in flat corneas

KC

- 37 y.o Chinese male – wants a second opinion, should he continue glaucoma eyedrops?
- LASIK OU 2007
- Glaucoma diagnosed at pre-LASIK evaluation and Xalatan was started OU
- Mother has glaucoma
KC

• Pre-LASIK
  – IOP 20 OD 22 OS
  – CCT 538 OD 540 OS
  – IOP on Xalatan 17 OD 18 OS

• Post LASIK
  – CCT 463 OD 485 OS
  – IOP on Xalatan 10 OD 13 OS
  – IOP off Xalatan 17 OD 18 OS

KC

• Va 20/25 ou
• IOP 14 OU
  - Took Xalatan in the past week but missed several weeks before that
• Anterior segment – LASIK flaps, otherwise normal
• Gonioscopy – Open to ciliary body OU
• 54 y.o. Caucasian male
• Referred for increased C:D ratio
• Past ocular history
  – s/p LASIK OU 2003
  – “Hooked discs” for a long time
• No family history of glaucoma
CD

- VA cSCL: 20/30 20/30
- IOP – GAT: 12 12
- IOP – Pascal: 10.7 11.8
Practical considerations

- GAT remains the most studied technique for the management of glaucoma patients
- Inform post-LASIK patients regarding challenges in IOP measurement.
- Pre-op CCT and IOP measurements may be useful.
- Obtain multiple IOP measurements at different times of day
- Periodically assess goal IOP based on overall clinical picture