HOW TO IMPROVE REFRACTIVE OUTCOMES WITH IMMERSION BIOMETRY?

Andrzej Dmitriew
Department of Ophthalmology
Poznan University of Medical Sciences
ACCURATE IOL CALCULATION

• 90-95% of patients within ±0,5 D
• Accurate biometry
  • Accurate ACD
• Accurate keratometry
• Formula selection
• Proper choice of predicted postoperative refraction
• Accurate IOL constants

• Uneventful surgery
ACCURATE BIOMETRY
(INCLUDING ACD FOR HAIGIS FORMULA)
BIOMETRY

- Acoustic (A-scan)
  - contact
  - immersion
  - immersion vector (A/B)
- Optical (interferometry)
ACOUSTIC BIOMETRY

- **Immersion**
  - Has been considered the most accurate for years – e.g. reference for Zeiss IOLMaster
  - Time effective
  - Complex disinfection

- **Contact**
  - AC shallowing
  - Epithelial damage
  - Off the axis
  - Time consuming
A-SCAN
OFF THE AXIS
IMMERSION BIOMETRY

- Possible with each probe (Immersion option)
- Scleral shell needs to be compatible with the probe
- Ergonomic source of liquid medium (BSS, Ringer, Saline)
- Easy connection is preferred
IMMERSION SHELLS

- Probe dedicated (permanent fixation)
  - Kohn (Ellex)
  - Prager (ESI)
  - Accutome
  - E-Z tip
- UBM shells (open)
IMMERSION - SETUP

• To-prepare-list
  • Immersion shell
  • Topical anesthetic
  • BSS (or saline, Ringer, etc.)
  • Tissues
  • Syringe or Intravenous transfusion set

• Equipment setup – Immersion mode
• Patient – horizontal (shell) or vertical positioning (ClearScan)
IMMERSION - SETUP
Immersion 1 Custom: C A P R
Phakic 1532 / 1641 / 1532 m/s : Phakic
AXL: 22.87mm  ACD: 2.78mm  Lens: 4.77mm
DIFFERENCE BETWEEN IMMERSION ACOUSTIC AND OPTICAL BIOMETRY

- Technology
  - Partial Coherence Interferometry (Zeiss),
  - Optical Low Coherence Reflectometry (Haag-Streit, Wavelight)
- ULIB (1999) - prof. Haigis (University of Wurzburg)
- Commercially available
  - Zeiss IOLMaster – since 1999
  - ESCRIS IX 2008 - Haag Streit and Wavelight
- Accuracy (SD) ±0,02 mm
BIOMETRY – FINAL REMARKS

Average ACD is considered to be 2,5 – 4,0 mm. If ACD decreases in sequentional measurements = corneal compression

1 mm of AL error = 3 D of postop refraction
FORMULA SELECTION
IOL CALCULATION FORMULAS

- SRK/T, SRK II (Sanders, Retzlaff and Kraff) and Holladay 1 (Jack Holladay) are most commonly used
- They are II and II generation formulas from 80s/90s
- SRK II (II generation) and SRK/T (III generation) use A constant
- Holladay 1 uses SF (Surgeon Factor)
## FORMULA SELECTION (POZNAŃ)

<table>
<thead>
<tr>
<th>AL (mm)</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20 mm</td>
<td>Haigis / opt. Hoffer Q</td>
</tr>
<tr>
<td>20-22 mm</td>
<td>Haigis / Hoffer Q / opt. Holladay I</td>
</tr>
<tr>
<td>22-24.5 mm</td>
<td>Holladay I / SRK/T</td>
</tr>
<tr>
<td>&gt; 24.5-26 mm</td>
<td>Holladay I = SRK/T</td>
</tr>
<tr>
<td>&gt; 26 mm</td>
<td>SRK/T / opt. Holladay I</td>
</tr>
</tbody>
</table>
1ST GENERATION FORMULAS

- Based on regression formulas developed by Sanders, Retzlaff and Kraff (SRK) - 1980
- \( P = A - 2.5(L) - 0.9(K) \)
  - \( P = \) IOL power (emmetropia),
  - \( L = AL \)
  - \( K = \) keratometry (D)
  - \( A = \) IOL constant (113-119)
2\textsuperscript{ND} GENERATION FORMULAS

SRK II formula

- Modification of SRK
- IOL power based mainly on AL

\[ P = A1 - 0.9 \, K - 2.5 \, L \]

- \( A1 = A + 3 \) for \( L < 20 \)
- \( A1 = A + 2 \) for \( 20 \leq L < 21 \)
- \( A1 = A + 1 \) for \( 21 \leq L < 22 \)
- \( A1 = A \) for \( 22 \leq L < 24.5 \)
- \( A1 = A - 0.5 \) for \( 24.5 \leq L \)
3rd Generation Formulas

SRK/T (1990), Hoffer Q, Holladay 1

- Further adjustments

Preference:
- SRK/T- very long eyes (>26mm)
- Holladay 1- long eyes (24 to 26mm)
- Hoffer Q – short eyes (<22mm)
4\textsuperscript{TH} GENERATION FORMULAS

Holladay 2

- 1996 - Jack Holladay
- Requires:
  - White-to-white
  - Corneal diameter
  - ACD
  - Lens thickness
  - Age
  - Preop refraction
- Most accurate
4\textsuperscript{TH} GENERATION FORMULAS

Haigis

- Wolfgang Haigis
- Included in Zeiss IOLMaster software for the first time
- 3 parameters $a_0$, $a_1$, $a_2$ (if $a_1 = 0.4$, $a_2 = 0.1$, then Haigis works as 3\textsuperscript{rd} generation formula)
- Constants are available at ULIB website (University of Wuerzburg)

Optimized Haigis

- $d = a_0 + (a_1 \times \text{ACD}) + (a_2 \times \text{AL})$
- $d$ – predicted lens position
FORMULA SELECTION

• 900 eyes – comparison of SRK I, II, /T, Holladay, Binkhorst II – SRK/T and Holladay I work best
  

• The use of SRK I i II should be stopped because of the poor postoperative results – worse than in SRK/T, Holladay 1 and Hoffer Q
  

• How accessible are Haigis and Holladay 2 (4th generation formulas)?
FORMULA SELECTION

- The Royal College of Ophthalmologists - Cataract Surgery Guidelines

<table>
<thead>
<tr>
<th>Axial length (mm)</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;22mm</td>
<td>Hoffer Q</td>
</tr>
<tr>
<td>22-24.5mm</td>
<td>Average of Hoffer Q, Holladay and SRK/T</td>
</tr>
<tr>
<td>24.6-26mm</td>
<td>Holladay</td>
</tr>
<tr>
<td>&gt;26mm</td>
<td>SRK/T</td>
</tr>
</tbody>
</table>

* Haigis and Holladay 2 were not considered
## FORMULA SELECTION (POZNAŃ)

<table>
<thead>
<tr>
<th>AL (mm)</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20 mm</td>
<td>Haigis / opt. Hoffer Q</td>
</tr>
<tr>
<td>20-22 mm</td>
<td>Haigis / Hoffer Q / opt. Holladay I</td>
</tr>
<tr>
<td>22-24.5 mm</td>
<td>Holladay I / SRK/T</td>
</tr>
<tr>
<td>&gt; 24.5-26 mm</td>
<td>Holladay I = SRK/T</td>
</tr>
<tr>
<td>&gt; 26 mm</td>
<td>SRK/T / opt. Holladay I</td>
</tr>
</tbody>
</table>
PROPER CHOICE OF PREDICTED POSTOPERATIVE REFRACTION
MONOFOCAL IOL – REFRACTIVE TARGET

- Postoperative refraction target
  - Emmetropia
  - -0.25 D
  - -0.5 D
  - -0.75 D
  - -1.0 D
- Error in postoperative refraction
  - ±2.0 D
  - ±1.5 D
  - ±1.0 D
  - ±0.5 D
MONOFOCAL IOL – REFRACTIVE TARGET

• Postoperative refraction target
  • Emmetropia
  • -0.25 D (-0.15 - -0.4)
  • -0.5 D
  • -0.75 D
  • -1.0 D

• Error in postoperative refraction
  • ±2.0 D
  • ±1.5 D
  • ±1.0 D
  • ±0.5 D
MULTIFOCAL IOL – REFRACTIVE TARGET

• Postoperative refraction target
  • Emmetropia
  • -0,25 D
  • -0,5 D
  • -0,75 D
  • -1,0 D

• Error in postoperative refraction
  • ±2,0 D
  • ±1,5 D
  • ±1,0 D
  • ±0,5 D
MULTIFOCAL IOL – REFRACTIVE TARGET

• Postoperative refraction target
  • Emmetropia
  • -0.25 D
  • -0.5 D
  • -0.75 D
  • -1.0 D

• Error in postoperative refraction
  • ±2.0 D
  • ±1.5 D
  • ±1.0 D
  • ±0.5 D
ACCURATE IOL CONSTANTS
IOL CONSTANT OPTIMIZATION

- To increase predictability of postoperative refraction
- Recommended in every surgical centre, however generally constants proposed by larger manufacturers work well
- Much easier with optical biometry device – data sent to Prof. Haigis in Wurzburg for the optimization
- Stable refraction is needed to be evaluated (6-8 weeks postop)
IOL POWER ACCURACY

- International Organization for Standardization (ISO) allows up to 1 D tolerance in IOL power
- Only a constant is present on the box
- No information is given whether it should be used for SKR II, SRK/T or for both
ATYPICAL SITUATIONS
IOL CALCULATION AND PRESBYOPIA

- Options for patient
  - Monovision
  - Multifocal lenses
  - Accomodative lenses
IOL CALCULATION AND PRESBYOPIA

• Monovision
  • Preferred refraction difference – max. 2.0 D, 1.5 D suggested
  • Mini monovision – ca. 1.0 D difference
  • Best approach
    • Dominant eye -0.25D
    • Nondominant eye -1.75 - -2.0D

• Multifocal IOLs
  • Emmetropia preferred
MULTIFOCAL IOLS
POSTOPERATIVE REFRACTION

- Emmetropia or smallest positive value preferred (Holladay J. Cataract & Refractive Surgery Today 8/2007)
- Small negative (up to -0.25D) and small positive values (up to +0.25D) give similar comfort – selection depends on the IOL addition (+3 or +4)
VITREORETINAL PATIENTS

- Encircling band makes the eye longer by 0.7-0.8 mm (own material presented at Euretina 2006) – has to be considered during IOL calculation process.
- IOL calculation is preferably based on the operated eye – measurement possible in both optical and acoustic biometry up to 2-3 mm detachment.
SILICONE OIL

• If there is no preprogrammed option for the presence of silicone oil, separate measurement of ACD, lens thickness and vitreous cavity may be necessary

$$AL = ACD + L + 980 \text{ or } 1040/1532 \times V$$

980 – sound velocity for SO 1000
1040 - sound velocity for SO 5000

$$\approx AL = ACD + L + 0.65 \times V$$

• ! – refraction issues (hyperopization), IOL issues (SO adhesion)
PIGGYBACKING

- Implantation of the second IOL into the eye
  - Primary – high hyperopia
    - IOLs over +35D are rarely manufactured
  - Secondary – postop refraction error
    - Sulcus implantation
    - Specific IOL calculation methodology
## SULCUS IMPLANTATION

<table>
<thead>
<tr>
<th>IOL power</th>
<th>Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>+28.5 to +30.0</td>
<td>-1.5D</td>
</tr>
<tr>
<td>+17.5 to +28.0</td>
<td>-1.0D</td>
</tr>
<tr>
<td>+9.5 to +17.0</td>
<td>-0.5D</td>
</tr>
<tr>
<td>+5.0 to +9.0</td>
<td>No change</td>
</tr>
</tbody>
</table>
IOL CALCULATION AND ASTIGMATISM

- SIA has to be predicted (especially if >1,0 D, best effects if <1,0D)
- Incision planning crucial for the outcome
- LRI >1,0D? -> no influence on IOL calculation (SE stable)
POSTREFRACTIVE KERATOMETRY

- Typical keratometry measurements may cause the refractive error up to 10D
- Many different methods (clinical history, Shammas, etc.) give different outcomes
- Haigis-L – simpliest?
SUMMARY

• Preoperative planning of postoperative refraction is the key to successful vision outcome, no matter which IOL is used

• Atypical situations (postrefractive eyes, silicone oil presence, very short eyes) can be managed by the experienced reference centre