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Intraocular Lens Decision Making

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Disclosure

- No financial interests in this presentation.

Background

- Cataract surgery is the most common procedure performed with more than 3 million procedures each year.\(^1\)
- Patient expectations with cataract surgery have changed:
  - From simply restoring vision
  - Increased emphasis on refractive outcomes and patient’s desire to be spectacle independent.
- Cataract surgery is also a leading source of malpractice complaints. In 2007 5% of Ophthalmologists insured by OMIC reported a claim.
  - Typically the wrong intraocular lens (IOL) is the culprit for more than half the “wrong” cases.\(^2\)

- Patient safety bulletin issued by AAO identified potential errors identifying why the “wrong” IOL is used.\(^3\)
  - Use of an outdated IOL formula or incorrect formula for axial length (AL)
  - Incorrect biometry
  - Incorrect data entry for IOL calculation program
  - Incorrect labeling or packaging of IOL
  - Mistakes in providing the IOL at time of surgery (switching IOL meant for another patient)
- Minimize error with a “Time Out” to confirm IOL before each case

Key Points

- Review optical biometry and IOL calculation formulas to improve post-operative refractive accuracy.
- Determine which IOL may be best for certain patients to improve their post-operative satisfaction.
- The most flawless surgery could be performed but if measurements are inaccurate or failure to understand patients' post-operative refractive goals – they may consider it a complication.

Biometry

- IOL power calculations depend on precise biometry for accurate outcomes.
  - In order to determine the power of the IOL, several values need to be measured:
    - Axial length (AL) of the eye
    - Corneal power or keratometry (K)
    - Effective lens position (ELP)
- The AL and K readings are measured pre-operatively and the ELP is then calculated using these measurements.
Ultrasound axial length measurements had been the gold standard for many years.

- Uses a 10 MHz sound wave to measure axial length.
- Look for steep retinal spike
- Slopping or steps in the retinal spike may indicate a misalignment error.

Applanation vs. Immersion

- Operator error may occur with direct applanation of the cornea.
- Indentation of cornea may induce error in axial length measurements.
- Immersion uses a fluid chamber where the ultrasound probe doesn’t come in contact with the cornea and can reduce error in axial length.
- Need keratometry readings (from topography) to calculate IOL power using the different formulas.

Partial coherence interferometry base biometry (Zemax IOL Master or Haag Streit LENSTAR) uses a 780 um infrared light wave that has 8x the resolution of a 10 MHz sound wave making measurement of axial length precise.

- Measures to center of macula giving the refractive axial length versus the anatomical axial length achieved with ultrasound biometry.
- Able to measure, corneal diameter, corneal curvature, and anterior chamber depth.

Partial coherence interferometry base biometry such as IOL Master can not be used for everyone.

- May not be able to capture measurements in patients with hypermature cataracts or patients who can not position appropriately.
- Require ultrasound axial length measurement.

Prior to taking measurements certain steps can be taken to improve accuracy.

- Recommend using artificial tears prior to taking the measurements to obtain a reliable topography and keratometry readings
- No contact lens use prior to taking measurements.
- 1 week for soft contact lens
- 3 weeks for hard contacts
- Contact lenses may induce corneal warpage with an appearance similar to keratoconus and keratometry results may change after not wearing them.
**Biometry**

- Need to analyze results to ensure accuracy.
- Axial lengths should be < 0.3 mm between the two eyes.
- If > 0.3 mm confirm the difference unless evidence suggests differently
  - Prior scleral buckle
  - Anisometropia
  - Keratoconus
  - Prior refractive surgery.

**IOL Formulas**

- The 3rd generation IOL calculation formulas require axial length (AL) and corneal power (K) obtained by optical biometry:
  - Hoffer Q
  - Holladay 1
  - SRK/T
- They use theoretical formulas rather than earlier regression formulas such as the SRK (P = A - 0.9K - 2.5L).

**Effective Lens Position**

- Differ in how they calculate the post-operative effective lens position (ELP).^3
- Holladay 1 and SRK/T formulas use a corneal height equation to predict post-operative ELP.
- Hoffer Q formula uses a different formula in which the tangent of corneal power is used.
IOL Formulas

- The third generation formulas (Hoffer Q, Holladay 1 and SRK/T) use a two-variable formula to predict the ELP based on axial length and keratometry.
- The two-variable formula assumes several factors that may result in inaccurate calculation:
  - Short eyes will produce a shallower ELP and a longer eye will have a deeper ELP
  - Flat K’s will result in a more shallow ELP and steeper K’s will result in a deeper ELP.

IOL Formulas

- The Holladay 2 formula was developed to more accurately determine the ELP and uses several additional variables to adjust the recommended IOL power:
  - Axial length
  - Keratometry
  - Horizontal corneal diameter
  - Lens thickness
  - Anterior chamber depth
  - Age
  - Preoperative refraction

Which Formula?

- Mean absolute error or deviation from predicted post-operative refractive error:
  - Hoffer Q most accurate with short axial lengths (<22mm)
  - Holladay 1 most accurate with average axial length (22mm - 26mm)
  - SRK/T most accurate with longer axial length (>26mm)
- Using the appropriate IOL formula can improve the accuracy of the refractive outcome.

Post-Refractive Surgery

- Post-refractive surgery (Lasik and PRK) may result in inaccuracies in post-operative refraction:
  - Post-myopic refractive surgery (Lasik and PRK) flattens the anterior cornea radius and leaves the posterior cornea mostly unchanged.
  - Keratometry overestimates the corneal power and underestimates the IOL power.

Post-Refractive Keratometry

- Standard keratometry measures an intermediate area and extrapolates the central corneal power.
- Corneal topography typically overestimates the central corneal power and underestimates the ELP, leading to hyperopic surprises.
- Important to counsel patient pre-operatively about these inaccuracies and the potential need for refractive correction after surgery.
A successful cataract surgery not only depends on optical biometry and IOL calculation but also the IOL type used to meet the patient’s post-operative desire and target distance.

- Monofocal IOL
- Toric IOL
- Multifocal IOL

Potential benefit in patients with prior refractive surgery including RK, PRK, or Lasik.

- Iaculius: T. et al used the ORA in a series of 246 eyes with a history of Lasik or PRK to determine the IOL power choice. 1
  - 87% within 0.50 D
  - 94% within 1.0D of predicted target
  - More accurate than Haigis-L or Shammas method.

Monofocal IOL targets one distance leaving individuals dependent on some post-operative correction.

- Pre-operative refractive error is important in deciding the target distance.
  - Aim for distance vision in both eyes with anticipation for reading glasses after surgery.
  - Beware of the -2.00 patients!
  - Aim for near vision in both eyes with anticipation for distance glasses after surgery.
  - Monovision outcome that respects ocular dominance, targeting the dominant eye for distance and the non-dominant eye for near vision.

Several different formulas have been developed for post-refractive surgery patients.

- The Aramberri Double-K method
- Haigis-L formula
- Shammas formula

To facilitate the process of determining which IOL power should be used the ASCRS website has a post-refractive IOL calculator that uses several different methods.

www.iolcalc.org
Toric IOL

- Toric IOL used for patients with astigmatism. Targets one distance leaving individuals dependent on some correction. Use for patients who are interested in spectacle independence even if for only one distance.
- Corneal astigmatism measured by corneal topography. Only corneal astigmatism needs to be addressed. IOLs may correct up from 1D – 4D.
- acrysoftoriccalculator.com or amoeasy.com
- Caution in patients with irregular astigmatism.
- Keratoconus
- Corneal ectasia
- Corneal scar
- May not be able to fully neutralize the corneal astigmatism.

Multifocal IOL

- Multifocal IOLs provide another option for patients who desire to be spectacle independent post-operatively.
- ReSTOR (apodized diffractive IOL with +3.0D add power)
- Tecnis Multifocal (full diffractive IOL with +4.0 add power)
- Inform patients that with a multifocal IOL they may not have absolutely crisp vision at multiple distances at all times and they must be prepared for the possibility of at least some visual distortions.
- Glare and halos around light sources at night
- Decreased contrast sensitivity
- Possibility of post-operative enhancements
- Astigmatism correction at time of surgery (> 0.75D).
Multifocal Candidates

Positive characteristics
- Easy-going personality with realistic expectations
- Willing to accept a few tradeoffs in exchange for reduced dependency on eyeglasses
- Younger patients with an active lifestyle
- High myopes

Negative characteristics
- Patients with unrealistic expectations
- Corneal dystrophies – Fuchs
- Macular pathology – epiretinal membrane or macular degeneration
- Specific occupations with heavy dependence on night vision
- Low myopes

Case 1

A 72 y/o female presents for blurry vision left eye.
- Visually significant cataract with BCVA 20/50.
- MRx: -7.00 + 0.50 x 85
- IOL Master with an AL of 27.25mm
- Which IOL Formula?
- SRK/T

Case 2

76 y/o male with visually significant cataracts is planned for surgery.
- MRx: -4.00 + 1.75 x 85 → 20/40
- Pre-operative corneal topography shows irregular astigmatism suggestive of keratoconus.
- Which IOL should you use?
  - Monofocal IOL with appropriate refractive target rather than using as toric or multifocal IOL.

Case 3

61 y/o male is scheduled for cataract surgery and the technician performs biometry.
- What’s wrong?
  - Change the IOL formula for the correct AL
  - Confirm the AL with immersion ultrasound (> 0.3mm).

Case 4

64 y/o female with history of myopic Lasik has recently developed a visually significant cataract in her right eye. She doesn’t have any pre-operative records. She elects to have a monofocal IOL.
- MRx: -2.25 + 0.50 x 112 → 20/50
- How do you want to counsel the patient?
  - Refractive target
  - Possibility of needing post-operative refractive correction
- What steps could you use to improve the post-operative refractive target?
  - Post-refractive IOL calculator on ASCRS website
  - Intra-operative ORA measurement

Summary

- Understand which IOL formulas to use in patients with various axial lengths.
- Understand modifications to the calculations needed in post-refractive state.
- Understand that with new technology we may be able to increase the accuracy by which IOL power is determined and the ELP.
- Determine the IOL type to meet patient’s post-op refractive goal.
References

1. Center for Disease Control and Medicare.