INTRODUCTION

- Intraocular lens (IOL) implantation in eyes of select children has become the standard of care during pediatric cataract surgery.
- Accurate determination of IOL power remains one of the major challenges.

Growth of the Eyeball

- At Birth – 16-17 mm
- At 1 yr – 20 – 21 mm
- At 6 yr – 23 mm
- At 10-15 yr- Stabilizes

Rapid Growth: 1st 3 months, AL = 18.23 mm
Slow Growth: till 15 yrs, AL = 23.6 mm
Most AL elongation – Ist 2 years of life
However judging the individual effect of each of these parameters is difficult.

Axial length (AL) and Keratometry (K) values are essential in calculating the IOL power.

**Techniques of measuring Axial length**

- **Optical biometry**
- **Ultrasound biometry**
- **Contact (Applanation)**
- **Immersion**

**Axial Length Measurement**

- **Applanation**
  - Indentation of Cornea
- **Immersion**
  - Not perpendicular to retina

Immersion scan eliminates corneal compression and has been shown to be superior to contact biometry in adults. It is accepted as a gold standard technique for axial length measurement.

*Trivedi RH et al. JCRS 2011*
Ultrasound Biometry

- Depends on US velocity setting
- AL of >25 mm best measured with 1550m/sec
- AL of <20 mm best measured with 1560m/sec
- Accurate measurement by setting average velocity of 1532m/sec and correcting for AL
- Corrected AL Factor (CALF) 0.32 added to AL

Hoffer KJ. JCRS 1994

Errors in axial length measurement are regarded as the most significant factor leading to incorrect selection of IOL power after cataract extraction.

- They can account for an error of 2.5 D/mm in IOL power, increasing to 3.75 D/mm, or even higher, in short eyes.

Measurement Tips ..

Important details to be kept in mind include
- Velocity (phakic / aphakic / pseudophakic)
- A constant
- Ensure good quality reading

Contact Vs Immersion Techniques

- Pediatric cataract surgeons use the contact technique more frequently. Immersion A-scan requires more experience and practice.

For those surgeons using contact A-scan techniques, is there a compelling reason to change to immersion A-scan with the increased technical expertise that the switch would require?
Axial length was measured by both contact and immersion techniques for all eyes, randomized as to which to perform first to avoid measurement bias.

Measurements using the contact technique were on an average 0.27 mm shorter than those obtained using the immersion technique. This difference was mainly the result of the anterior chamber depth rather than the lens thickness value.

If axial length measured by contact technique is used, it will result in the use of an average 1-D stronger IOL power than is actually required. This can lead to induced myopia in the postoperative refraction.

“If you must use applanation biometry, rely on the measurement with the greatest anterior chamber depth,” – Trivedi et al Ophthalmology 2011;118:498–502

This study is limited by the fact that the axial length measurement was performed under anesthesia without the benefit of visual fixation on the red light target within the A-scan ultrasound machine.

However, this is the only available option to measure axial length in young children.

Striking difference in axial length measurements when comparing the contact and immersion A-scan techniques, with the immersion group measuring an average of 1.06 mm longer.

All measurements were performed using the handheld contact A-scan probe, with the patient supine under general anesthesia.

This likely leads to more indentation of the cornea compared with performing the contact technique in a more controlled manner, with a table-mounted unit on a seated adult patient.

AL measured by the contact technique was significantly shorter than the AL measured by the immersion technique (22.2 mm versus 22.5 mm; P 001) in the same eye.

The IOL power for emmetropia was 1.2 D stronger with the contact technique than with the immersion technique (25.8 D versus 24.6 D; P 001).

The mean prediction error was +0.4+/-0.7 diopter (D) in the contact group and -0.4+/-0.8 D in the immersion group (P <.001) and the mean absolute prediction error, 0.7+/-0.4 D and 0.7+/-0.6 D, respectively.

We may be able to minimize postoperative myopic prediction errors in refraction by routinely using immersion A-scan for children having cataract surgery.
We found no significant difference in absolute prediction error between the contact and immersion A-scan biometry techniques (0.7 D and 0.7 D, respectively).

Ben-Zion et al also found no significant difference in absolute error (1.11 D and 1.03 D, respectively).

Tromans et al report a mean absolute prediction error of 1.4 D with contact A scan.

Nihalani and VanderVeen report a mean absolute prediction error of 0.76 D using the Holladay 1 formula.


Reliability and validity of PCI (IOL Master) for measurement of ocular axial length in children

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<th>A SCAN (MM)</th>
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Gursoy et al VOL. 88, NO. 8, PP. 912–919 OPTOMETRY AND VISION SCIENCE

Optical Biometry

IOL Master (Carl Zeiss Meditec, Germany), Lenstar LS 900 (Haag-Streit AG, Switzerland)

- Has gained popularity because of its non-contact feature, increased accuracy, and provides more information on ocular biometry.
- Uses light instead of sound for the measurement; the shorter the wavelength the more precise the measurement.
- Depending on the measured intraocular distance, precision values ranging from 0.3 to 10 m using PCI technology have been reported.

Lenstar Versus Ultrasound for Ocular Biometry in a Pediatric Population

- 565 school children were included

- Mean difference between pachymetry and Lenstar was 13.20±/- 13.13 m[95% confidence interval (CI): 12.01 to 14.37].

- Mean difference between ASU and Lenstar was 0.72±/- 0.35 mm (95%CI: 0.75 to 0.69) for AL, 0.27±/- 0.32 mm (95% CI: 0.30 to 0.24) for ACD, and 0.24±/- 0.28 mm (95% CI: 0.22 to 0.27) for LT

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**Lenstar Versus Ultrasound for Ocular Biometry in a Pediatric Population**

Longer AL with the Lenstar:
- The absence corneal indentation
- Ultrasound is reflected from the ILM, whereas PCI is reflected from the RPE.

Because ultrasound does not depend on patient fixation, it measures the anatomical length of the eye, from the corneal vertex to the posterior pole, whereas the Lenstar measures the optical length. In high myopia, the difference between the anatomical and optical length is increased, and this can be a possible explanation for the longer AL measurements obtained with ultrasound in some studies.

**Advantages of Lenstar over Ultrasound Biometry**
- The contact procedures caused anxiety
- The non-contact feature of the Lenstar eliminates possible corneal indentation
- The Lenstar is more user independent
- Measurement of the true optical length of the - higher accuracy

A well-known disadvantage of PCI technology is its inability to obtain measurements in eyes with dense cataracts and in those that cannot fixate on the red light of the instrument because of inadequate vision. This may be overcome by the latest DCM mode of the Lenstar.

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**‘K’ in Children**
- **Ehlers et al** - 47.50 D as a mean value for mature infants and 43.69 D for children aged 2 - 4 years. They concluded that corneal curvature reaches the adult range at about 3 years of age.
- **Inagaki** reported a rapid change in mean curvature from 49.01 D to 45.98 D during the first 2 to 4 weeks of life, which slowed after 8 weeks (44.60 D) and then stabilized at 44.05 D at 12 weeks after birth.
- **Asbell et al** - mean corneal curvature of newborns as 47.59 D. This decreases to 46.30 D (6- to 12-month age group), drops further to 45.56 D (12- to 18-month age group), drops to 42.69 D (54- to 90-month age group)
- Girls having steeper corneas than boys

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**‘K’ in Children with Cataract**
- Significantly steeper K values from birth to 6 months of age when compared with older children
- In unilateral cataract were steeper than those of bilateral cataracts.
- Eyes with PFV are steeper than the average for normal eyes at that age

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Most significant changes - 1st 6 months of life
• With a manual keratometer in older children when it is possible to take awake measurements
• Under general anesthesia using a handheld Auto Keratometer in very young children.

• To avoid the problems associated with corneal dryness, measurements to be taken as soon as possible after the induction of anaesthesia, and
• Balanced salt solution instilled as necessary to maintain a smooth corneal surface.
• Without the use of an eyelid speculum.

Take multiple readings till you get 2 or 3 readings within 1D, and select one reading from that.

• Noonan and colleagues found that the Nidek automated keratometer was accurate, reliable, and easy to use, and its results compared favorably with that of the manual Zeiss keratometer (Carl Zeiss Vision, Jena, Germany) when measuring corneal curvature.
CHALLENGES

- Managing pediatric aphakias have always presented with challenges
- Whatever is the cause of cataract, surgical removal and optical rehabilitation have been the main stay of treatment
- Recently, with improving surgical techniques, acceptable age for placing an IOL is getting younger

Refractive goals and challenges

- Anticipate myopic shift
- ?? How much at what age
- Target Refraction
- Early IOL Implantation

Advantages
- Optimal visual rehabilitation
- Improved visual acuity, BSV, reduced strabismus
- Maximises visual outcome in unilateral cataract
- Visual axis opacification

Disadvantages
- Visual axis opacification
- Myopic shift

Target Refraction

Anticipate myopic shift

?? How much at what age
Controversies

- Significant amount of variation in rate and amount of refractive change is well recognized and poses a problem in selection of correct IOL power.

- Lack of accurate IOL power formulae which takes into account the smaller pediatric eyes and variable factors.

Early postoperative refractive outcomes of pediatric intraocular lens implantation.

Growth of the Eye Ball

- K reading: 51 D at birth which stabilizes at 6 months of age with minor change after that.
- Lens power: drops by 10 D in first year of life, then drops by only 4-3D from 2 to 10 years of age
- Hence lens power drops from 34.4 D at birth to 18.8 at 10 years of age.

Gordan Donzis showed more than 90% of the growth of the eye ball is complete during the first 18 months after birth.


Infant vs Adult Eye

- 16.6 mm
  - NEWBORN
  - 1st three months
  - Rapid growth
  - 18.23 mm
- Final avg
  - 23.6 mm
  - 15 years
MYOPIC SHIFT

Causes

- Visual Deprivation
- Amblyopia
- Axial elongation - Fixed IOL power and change in IOL position in growing eye
- Heredity Factors
  - Myopic shift is directly related to normal eye growth in eyes in fixed IOL power

Myopic shift depends upon

- Normal axial growth along with
- Age at surgery
  - Presence/ absence of IOLs
- Laterality
- Intraocular axial length differences
- Genetic factors

Target post Operative refraction

Based on

- Patients age & fellow eye status

General Recommendations

- +12 D in first month of life
- +8 to 10 D the second to third month of the life
- +6 D in four to six months of life
- +4 D in six to 12 months of life

Post Operative Target refraction

- No agreement in the literature on ideal target refraction in infants & children after IOL implantation
- Several studies have recommended IOL power, undercorrection and target refraction based on long term experiences
- Gimbel et al. recommends IOL power close to predicted for immediate emmetropia
Recently Hoevenaars et al yielded the following equation using multiple regression analysis including prediction error and myopic shift:

\[
\text{Amount of myopisation: } -7.97 + 0.05 \times \text{age at surgery} + 0.97 \times \text{bilaterality}
\]

higher expected myopic shift in younger children and unilateral cataract.

Br J Ophthalmol 2011

Factors affecting IOL power calculation:

- **Age**
  - Closer to birth, more undercorrection will be needed
  - Initial 1 year requires 20-25% of correction

- **Status of fellow eye**
  - B/L cataract can be left more hypermetropic as non-compliance of glasses will be less amblyogenic
  - If the fellow eye is pseudophakic, refractive error of other should be kept in mind

- **Visual acuity**
  - Densely amblyopic eyes → more towards emmetropia so as to emphasize occlusion therapy
  - Myopia is acceptable

Choosing an IOL Power:

- There is no accurate IOL power formulae which calculates the IOL requirement in pediatric age group as most of them are not accurate for smaller eyes.
- Prediction of myopic shift is difficult

- Poor compliance to glasses, contact lens in amblyogenic age
- Parental refractive error: anticipating more eye growth, these patients can be left more hypermetropic
- IOL power, Site of IOL placement
Emmetropia vs Hypermetropia

- An IOL calculated to achieve emmetropia will lead to myopia in later months.
- A hyperopic target refraction can lead to amblyopia in the early postoperative months.
- A balance between amblyopia, future refractive and refractive error in the fellow eye should be considered.

High Prediction Errors

- Measurement of axial length and keratometry in infants under GA.
- The desired residual hyperopia necessary to compensate for myopic shift.
- Axial length position and anterior chamber depth.
- Corneal radii.
- Age at time of Surgery.

Conclusion

- Although pediatric IOL power calculations suffer from significant prediction error, these errors can be decreased by careful preoperative measurements.
- IOL power calculation formulas are most accurate in the older, more 'adult'-sized eye.
- The smallest eyes have the most prediction error with all available formulas.
- Individual circumstances and parental concerns must be factored into the choice of a postoperative refractive target.

THANK YOU
Considerations for secondary IOL implantation in child

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Eyes that are left aphakic require a secondary IOL implantation. Even if the surgeon is not planning to implant an IOL primarily, it is important to leave behind sufficient anterior and posterior capsular support at the time of cataract surgery to facilitate in-the-bag or sulcus fixated IOL implantation when the child and the eye grow.

Secondary implantation of IOL is recommended when noninvasive modes of correcting aphakia have failed, but still there is hope to reverse amblyopia.

We prefer to implant secondary IOL once child is 3 years old.

Ultrasound bio microscopy (UBM) helps to detect residual capsular support and image the ciliary sulcus when viewing it directly is difficult.

A complete ophthalmic examination including visual acuity, slit lamp biomicroscopy and fundus examination after mydriasis should be performed as and when required under anaesthesia. The shape and size of pupil, presence of posterior synechia and vitreous in the anterior chamber should be documented preoperatively.

Biometry

• Biometry is one of the most critical steps in modern cataract surgery, what matters most is achieving excellent results.*

• Biometry in pediatric eyes is very challenging.

Special circumstances

• Traumatic cataract
• Artisan IOL
• Toric IOL
• Post keratoplasty
• Keratoconus

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Bioptometry in special circumstances

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Boston, MA

• Biometry is one of the most critical steps in modern cataract surgery, what matters most is achieving excellent results.*

• Biometry in pediatric eyes is very challenging.

**Traumatic cataract**

- Keratometry not possible owing to corneal scars and distorted mires
- Use keratometry of other eye
- Corneal Topography

**Artisian IOL**

- Van der Heijde formula, which uses the mean corneal curvature, adjusted ultrasound central ACD and spherical equivalent of the patients’ cycloplegic correction at a 12-mm vertex
- Users can access dioptric powers by the Ophtec site through Ophtec’s online Artisan and Artiflex lens calculation program

**Toric IOL**

- Accurate measurement of total corneal astigmatism
- Traditional keratometers, Placido-disk corneal topographers, IOL master, Lenstar- measure anterior corneal curvature
- Placido-dual Scheimpflug analyzer (Galelei, Pentacam)

**Corneal Topography**

- Placido disk reflection
- Scanning slit
- Scheimpflug
Toric IOL

- The total corneal power (TCP) astigmatism value, which is the difference between the steep TCP and flat TCP at the 1.0 to 4.0 mm central zone used
- Holladay 1

Post keratoplasty

- High regular and irregular astigmatism and significant other refractive error
- Scheimpflug Topography to get K values
- Better results if sutures are removed before cataract surgery

Keratoconus

- Highly irregular corneal astigmatism
- Precise measurement of K values
- K readings become unstable after corneal incision for cataract surgery, even in preoperative non-progressing keratoconus
Keratoconus

- Topography based K values
- SRK/T