

Chapter 9

Calculation of Intraocular Lens Power



Stacey J. Kruger

The selection of intraocular lens (IOL) power in children is decidedly different and more complex than when making similar choice in adult patients. The choice of IOL power is driven by many factors such as the age of the patient at surgery, the presence of unilateral or bilateral cataracts, the refractive error of the fellow eye, the physical properties of the eye including corneal size and axial length, and the presence and density of preexisting amblyopia. It is also important to consider the growing/changing eye in childhood and how these changes will translate into challenges managing resultant amblyopia.

Biometry and Keratometry

Technically, IOL calculation is performed in infants and most children during an eye exam under anesthesia (EUA) due to the limited cooperation one usually encounters in the office setting, rendering these tests unfeasible without sedation. The instrumentation that is used therefore needs to be portable for ease of manipulation and transportation to the operating room (OR). In this setting, the results of biometry are often less accurate as the asleep child cannot voluntarily fixate their gaze with the axis of measurement. It is often difficult and time-consuming to obtain keratometry readings, but it can be worthwhile to obtain three or more measurements per eye. The surgeon should select several readings that appear mathematically similar to the average of collected list of numbers. The accuracy of axial length determination is critical as even small errors in measurements can lead to large discrepancies in the postoperative refractive state as they are magnified by the

S. J. Kruger (✉)

Zucker School of Medicine at Hofstra/Northwell Health, Department of Ophthalmology,
Division of Pediatric Ophthalmology, Great Neck, NY, USA
e-mail: skruger1@northwell.edu

various IOL calculation formulas. For determination of axial length, immersion A-scan measurements are preferred as they limit compression errors induced by contact A-scan.

IOL Formulas

There are numerous formulae for IOL calculation in use today, which are based on use in adult eyes. There has been significant research seeking to validate the use of one formula over another in the pediatric population. One such paper by Vanderveen et al. evaluated Hoffer Q, Holladay 1, Holladay 2, Sanders-Retzlaff-Kraff (SRK), and Sanders-Retzlaff-Kraff theoretic (SRK/T) formulae in infants that received IOL implantation at age 7 months or younger in the pseudophakic arm of the Infant Aphakia Treatment Study [1]. In this report, 43 eyes were studied with a mean axial length of 18.1 ± 1.1 mm. This study found that the Holladay 1 formula showed the lowest median absolute prediction error, while a paired comparison of medians showed similar results between Holladay 1 and SRK/T. The study is most applicable to infants undergoing primary IOL implantation, as the mean age of the study group was 2.5 ± 1.5 months. Another study by Trivedi et al. evaluated 45 eyes of children who underwent IOL implantation at a mean age of 3.56 years [2]. In this study there was a low mean absolute error of 0.68–0.84 D with the Holladay 2 formula giving slightly better predictions.

Axial Elongation and Myopic Shift

Another parameter that makes selecting an IOL for a pediatric patient challenging is the anticipation that the eye will grow during the child's lifetime. The human eye usually undergoes 3–4 mm of axial elongation in the first year of life, as well as corneal flattening and a reduction in lens power. Axial elongation was also studied in the Infant Aphakia Treatment Study. Axial length was measured before cataract surgery and again at ages 12 months and 5 years [3, 4]. In the first year, the rate of axial elongation was found to be nearly constant at a rate of 0.17 mm/month in the aphakic arm ($n = 57$), while in the pseudophakic arm ($n = 57$), the rate of elongation was found to be 0.24 mm/month [3]. In both groups, this rate was independent of age at surgery. In contrast, the rate of growth of normal fellow eyes decreased with older age at surgery. It is important to note that eyes with cataracts were shorter than fellow eyes at the time of surgery. Patients with glaucoma or suspected glaucoma were excluded, as this condition in infants is known to cause axial elongation. The same groups were then again reanalyzed at 5 years. Axial length was significantly different between treated and fellow eyes preoperatively (18.1 vs. 18.7 mm, $P < 0.0001$) and at 5 years follow-up (21.5 vs. 22.1 mm, $P = 0.0004$) [4]. The difference in axial length growth between treated and fellow eyes was not significant.

The change in axial length between the two arms (CL and IOL) was not significant between treatments. It is therefore important to remember when selecting an IOL for a patient with a monocular cataract that, although the rates of growth may be similar, a preoperative difference in axial length may persist throughout childhood.

Another important consideration is that as a pseudophakic eye elongates, myopia becomes magnified due to the optics of the IOL. As the eye grows, the focal point of the IOL moves forward, and as a result of the increased distance between the lens and the retina, the eye grows more myopic.

Secondary IOL

In children undergoing secondary IOL placement, special consideration should also be given to the calculation of lens power. Although most children undergoing this procedure are older, measurements are frequently still taken in the OR on the day of surgery with the patient under general anesthesia as described earlier. Moore et al. reviewed 50 consecutive eyes undergoing secondary IOL implantation at a single institution [5]. IOL calculations were made assuming “in the bag” positioning and then reduced by 0.5 D if placement in the ciliary sulcus was required. Despite the uniformity of EUA and IOL calculation procedures, patients still showed variability in predicted versus actual postoperative outcomes. In this study, the mean patient age at surgery was 6.5 years (range 0.6–15.0). The predicted postoperative refraction was $+1.69 \pm 1.85$ D, whereas the actual postoperative refraction was $+1.23 \pm 1.25$ D with a mean absolute value of prediction error of 1.64 ± 1.58 D. This resulted in a difference of 1.5 D in actual versus predicted postoperative refraction.

Lastly, a decision for placement “in the bag” versus the ciliary sulcus should be considered when placing a secondary IOL. This will likely be based on the status of the capsular bag. If the edge of the anterior capsule is not well visualized for 360° or the size of the anterior and posterior capsulotomies at the time of the original surgery were large, sulcus placement is recommended. A large retrospective review of secondary in the bag lens implantation was performed by Wilson et al. in which 10 years of data at a single institution were analyzed [6]. Patients receiving sulcus placed secondary IOLs during the same time frame were also analyzed. The mean pre- and postoperative spherical equivalents were not statistically significant when analyzed in patients with at least 6 months of postoperative follow-up.

Case Report

A 3-year-old girl presented to the office with a family history of bilateral congenital cataracts in her older brother, now age 8 years. She had been seen elsewhere 1 year prior and found to have high myopia for which she was prescribed glasses that she never wore. At the time of the exam, the patient’s vision was 20/30 OD and 20/40

OS tested using Allen pictures. The patient was found to have bilateral lamellar cataracts that were clear in appearance. There was a good view of both fundi, which appeared normal. Refraction was found to be $+1.50 + 0.50 \times 90$ OD and $+1.50 + 1.00 \times 90$ OS. It was decided to follow the patient closely for changes in her vision and/or refractive state. The patient's exam was the same 3 months later, but after another 3 months, her vision had decreased to 20/80 and 20/150 in the right and left eyes, respectively. The appearance of the lenses had changed, the lamella now significantly opacified OS>OD. An EUA was performed, and the cataract was removed from the left, poorer seeing eye, first. A decision to place an IOL with the family had been made. The patient's K's were 44.00 and 46.50 in the right eye and 43.50 and 46.00 in the left eye. The axial lengths measured 21.02 mm and 20.41 mm in the right and left eyes, respectively. IOL calculations were made using the Holladay I formula since the patient's measurements were fairly average. A +27 D lens was placed in the bag during surgery. The patient's postoperative refraction approximately 2 months later was $+1.50 + 1.50 \times 105$.

Comment In this case, the patient was intentionally left with a postoperative target refraction of approximately +3.00 D. Placing a +30 D lens would have left the patient +1.15 D, somewhat closer to emmetropia and with a relatively symmetric refraction compared with the fellow eye. However, the second eye surgery had already been planned for a future date at the time of the first surgery, and it was therefore felt it would be easy to match the +3.00 target refraction in the fellow eye. As discussed earlier, higher-powered IOLs, especially those over +30 D, can magnify the myopic shift as the patient grows. The parents were counseled regarding the myopic shift and were fortunately very knowledgeable about this since their older son, who had surgery early in life, now wore glasses to correct his moderate myopia.

The patient's postoperative actual refraction was somewhat less than targeted. It is possible that the "surgeon factor" was off in this case, as this was the first case by this author with a new contact A-scan device versus an immersion A-scan ultrasound that was used at a prior institution. The postoperative cylinder is felt related to the persistence of an absorbable suture remaining at the wound and may flatten over time.

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