INTRAOCULAR LENS POWER CALCULATIONS BEFORE CATARACT SURGERY IN PEDIATRIC PATIENTS

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Abstract

At birth, normal eye is rarely emmetropic. At two years, the mean value shifts so that the eye becomes closer to emmetropia .This process is called emmetropization , and within populations, it's possible to predict shifts in refractive error so that most infants are born hyperopic and become near emmetropic by 6-8 years of age.

Cataract is regarded the most common lens abnormality. Congenital cataract responsible for nearly 10% of all visual loss in children worldwide. The etiology of the vast majority of the cataract is unknown.

Among the problems which arise regarding the use of intraocular lenses (IOLs) in the pediatric population is the question of the power of the implant that should be used considering the expected growth of the child's eye.

A number of formulas for IOL power calculations have been published; all these formulas are based on an accurate measurement of the corneal power and of the axial length. In a recent study it was shown that the SRK/T formula was more accurate than empirical formulas in calculating IOL power in short eyes and they found increasing prediction error for shorter eyes in their series.

Key Words:

Development of the eye and ocular growth, Basic optics for IOL power calculations, Choice of IOL power in pediatric cataract.

List of abbreviation

ACD	**Anterior Chamber Depth.**
AL	Axial length.
cc	cubic centimeter.
D	Diopter.
ELP	Estimated Lens Position.
IOL	IntraOcular Lenses.
K	Keratometric Reading.
LOPT	Optical Axial length.
mm	millimeter.
PCI	Partial Coherence Interferometry.
PMMA	Polymethyl Methacrylate.
RETHICK	Retinal Thickness.

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Introduction

The lens of the human eye is a transparent, biconvex, elliptical, semisolid, avascular body of crystalline appearance located between the iris and the vitreous. At birth, the lens is almost spherical, being slightly wider at the equatorial plane [1].

Cataract is regarded the most common lens abnormality. Congenital cataract is responsible for nearly 10% of all visual loss in children worldwide. The etiology of the vast majority of the cataracts is unknown; fortunately however cataracts caused by specific entities are easily identified [2].

Among the problems which arise regarding the use of intraocular lenses (IOLs) in the pediatric population is the question of the power of the implant that should be used considering the expected growth of the child's eye. The majority of the eye growth takes place in the first 18 months of life after which there is little change [3]. A number of formulas for IOL power calculations have been published; all these formulas are based on an accurate measurement of the corneal power and of the axial length (AL). The original formulas were then modified in the 1980s to correct the errors in the short and long eyes. Although these formulas are rarely used these days, they are the basis of all modern formulas [4].

Variables including; axial length, anterior chamber depth, corneal curvature, predicted IOL position, desired refractive outcome, and surgeon technique should be taken into consideration in calculating the power of the IOL. It is obvious that with current biometers and newer formulas it is realistic to expect outcomes in the range of ±0.25 diopters for most patients [5].

The changes in the axial length during childhood following implantation of IOLs create difficulties regarding the choice of the power of the appropriate intra ocular lens [5]. Most authorities recommend implanting an IOL with a power that will undercorrect a child 6 years of age or less, but fully correct a child 6years of age or older . Multifocal IOL implantation in children is still under trials [6].

Development of the eye and ocular growth

Ocular development

The eye is one of the first organs recognizable during embryogenesis. At birth, development is incomplete.Concerning postnatal growth, development, and organization of the eye and the whole visual pathway to the cortex is important for the normal development of vision[7].

In the first three weeks of embryonic development, the two main processes that occur are the differentiation of cell type into endoderm, mesoderm and ectoderm and the organization of these tissues into a tube like notochord/neural tube structure [8].

At day 22 an optic groove forms within the lumen of the forebrain. Over the next 3 days, the neural tube closes at its caudal and cephalic ends. At day 25 the optic groove has formed in the optic vesicle, which evaginate toward the surface ectoderm, initiating the lens placode. The optic vesicle then begins to invaginate, forming a double layered optic cup lined by the two layers of the neuroectoderm.At 7 weeks, the eye has an optic nerve, two-layer retina, and primary lens vesicle. It is surrounded by mesenchyme and neural crest cells, which differentiate into sclera, choroid, iris, cornea, and vitreous between 7 and 15 weeks of age [9].

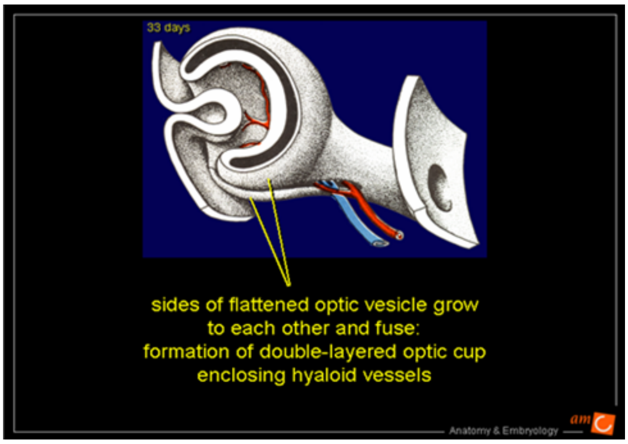

Figure 1; Shows a diagrammatic representation of the development of the human optic cup [10].

At birth, normal newborns have the following ocular parameters: axial length 16.8mm, corneal steepness 55 diopters, and lens power 34 diopters[7].

Newborn vs. adult ocular parameters		
	Newborn	Adult
Axial length	16.8mm	23.00mm
Mean K	55	43
Optic nerve length	24mm	30mm
Corneal diameter	10.0mm	10.6mm vertical by 11.7mm horizontal
Corneal thickness	0.581mm	0.510 mm
Pars plana length	0.5-1.05 mm	3.5-4mm
Orbital volume	7 cc	30 cc

Table 1; shows the newborn versus the adult ocular parameters [7].

Postnatal growth and emmetropization

At birth, the eye is rarely emmetropic. The optical refractive determinants of the eye-corneal curvature, lens power and location, and axial length –can be quite variable so that the refractive error of the newborn eye ranges from between -2.0 and +4.0 diopters[11]. Within two years, this variability of refraction decreases and the mean value shifts so that the eye becomes closer to emmetropia .This process is called emmetropization , and within populations, it's possible to predict shifts in refractive error so that most infants are born hyperopic and become near emmetropia by 6-8 years of age. As the cornea flattens, it loses refractive power, which is balanced by increasing axial length[12].

Basic Optics for Intraocular Lens Power Calculations

Intraocular Lens Power Calculations

Intraocular lens power calculations have become an integral part of the preoperative cataract evaluation. During the past two decades, formulas used for such calculations have evolved to a high level of accuracy. All available formulas aim to calculate the exact power of an intraocular lens (IOL) that will produce postoperative emmetropia. After surgery, the two major refracting elements inside the eye would be the cornea and the IOL. Both act as plus lenses and these curved surfaces will refract the incoming rays of light, focusing them on the retina, thus reaching emmetropia [13].

Refractive Power of the Curved Surface:

Refraction is the bending of light as it travels from one medium to another. The interface between the two media is the refracting surface. The refractive index (n) of a transparent material is the ratio of the speed of light in vacuum to the speed of light in that material [14].

Optics of the Thin plus Lens:

A thin plus lens is characterized by its power, expressed in diopters (D). It indicates the amount of vergence produced by the lens. Each lens has a primary focal point and a secondary focal point. The primary (front) focal point is the point along the optical axis at which an object must be placed for parallel rays to emerge from the lens[14].

If parallel rays hit a plus lens, the exiting rays will converge to a specific point; this point is called the secondary (back) focal point. The distance between each of the primary and secondary focal points and the center of the lens is the focal distance[14].

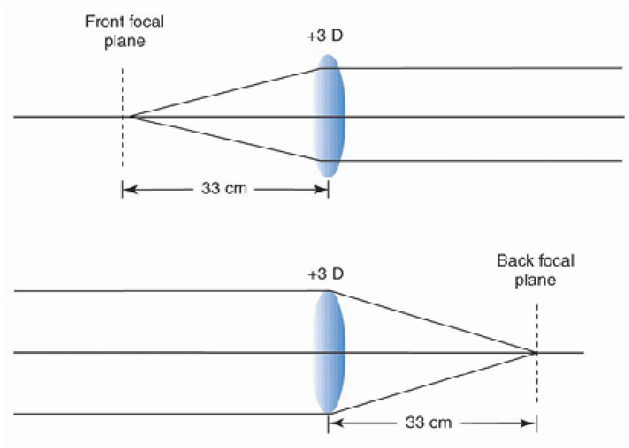

Figure 2. Focal planes of a plus lens [15].

The Two-Lens System:

In the presence of a two-lens system, it becomes a little bit more difficult to calculate the object-image relationship. The vergences have to be calculated in succession, dealing first with the first lens to encounter the incident light. The image position created by the first lens will then be the object position for the second. In the operated eye, the incident light is traveling in air (index of refraction of 1.00). These rays first meet the cornea that has a known power (K). The vergence formula for the first lens becomes U + K = V[16] .