Chapter 13
Primary Intraocular Lens Implantation

Natalie C. Weil and Scott R. Lambert

Primary intraocular lens (IOL) implantation is performed when a cataract is removed and an IOL is implanted at the time of cataract surgery. Cataract surgery is recommended for any visually significant lens opacity in a child. It should be performed at 4–8 weeks of age for infants with a unilateral visually significant cataract and at 6–8 weeks of age for infants with bilateral visually significant cataracts. While cataract surgery at even earlier ages may result in improved visual results, it is generally not recommended because of the increased risk of adverse events associated with cataract surgery before 6 weeks of age [1–3]. When cataracts are diagnosed after age 8 weeks, cataract surgery should be performed as soon as possible because of the risk of amblyopia worsening with a delay in treatment. Bilateral immediate sequential cataract surgery is advocated in many situations for young children to expedite their visual rehabilitation and to reduce their exposure to general anesthesia, with appropriate precautions taken to minimize the risk of bilateral endophthalmitis and toxic anterior segment syndrome [4].

Primary IOL Versus Aphakia

Primary IOL implantation is generally performed at the time of cataract surgery for children 1 year of age or older [5]; however, there remains controversy as to whether IOL implantation in children less than 1 year of age is the best surgical decision.

N. C. Weil
Pediatric Ophthalmology & Adult Strabismus, Emory Eye Center, Atlanta, GA, USA
e-mail: nweil@emory.edu

S. R. Lambert (✉)
Stanford University School of Medicine, Stanford, CA, USA

Lucile Packard Children's Hospital, Palo Alto, CA, USA
e-mail: lambert7@stanford.edu

© Springer Nature Switzerland AG 2020

C. L. Kraus (ed.), *Pediatric Cataract Surgery and IOL Implantation*,
https://doi.org/10.1007/978-3-030-38938-3_13

The Infant Aphakia Treatment Study (IATS) found that infants less than 7 months of age who underwent primary IOL implantation experienced more adverse events and required more additional intraocular surgeries than children left aphakic and corrected with contact lenses. Most pediatric cataract surgeons in high income countries do not perform primary IOL implantation in infants less than 7 months of age unless there are social factors that would make contact lens correction difficult. In low income countries, primary IOL implantation is more commonly performed during infancy because of the limited availability of aphakic contact lenses.

In addition to social factors, the size of the eye must also be taken into consideration when deciding whether primary IOL implantation should be performed. Eyes with corneal diameters less than 9 mm should be left aphakic until the eye grows to an adequate size to accommodate an IOL since most commercially available are not sized appropriately for small eyes.

Lens Power Selection and Refractive Goal

One of the most challenging facets of primary IOL implantation in children is determining the most appropriate lens power to implant. Since the eyes of young children are rapidly growing, implanting an IOL that targets emmetropia at the time of cataract surgery may result in a large myopic refractive error only a few years later. For this reason, most pediatric cataract surgeons target hyperopia (undercorrection) for the eyes of children at the time of cataract surgery [6]. A variety of recommendations for IOL powers in children have been made based on estimated ocular growth with a goal of emmetropia between 7 and 10 years of age [7–9] (Table 13.1). Table 13.2 represents authors' preference.

When patients are undercorrected at the time of primary IOL implantation, they should have their residual refractive error corrected as soon as it can be accurately determined. Children who are <2 years of age should be given single vision glasses with a near-point correction. Children older than 2 years of age should be corrected

Table 13.1 Postoperative target refraction tables for residual hyperopia in children

Age at surgery (years)	Enyedi 1998 [7]	Crouch 2002 [8]	Plager 2002 [9]
<1			
1	+6	+4.0	
2	+5	+3.5	
3	+4	+2.5	+5
4	+3	+2.5	+4
5	+2	+2.0	+3
6	+1	+2.0	+2.25
7	Plano	+1.0	+1.5
8		+1.0	+1.0
10		Plano	+0.5[a] + 0.5%

[a]Emmetropia or slightly myopia after age 10

Table 13.2 Authors' target refractions in pediatric cataract surgery

Age at surgery	Target refraction for residual hyperopia
1 year	+5
2 years	+4
3 years	+3.50
4 years	+3
5 years	+2
6 years	+1.50
7 years	Plano

for emmetropia and given a bifocal segment for near correction. Children that have unilateral aphakia can be corrected with a contact lens using the same age guidelines; children who are <2 years of age should be corrected with a contact lens for near-point correction and those older than 2 years of age should be corrected for emmetropia with a contact lens and given a bifocal segment for near correction.

Placement of Intraocular Lens

Intraocular lenses can be placed in the capsular bag and sulcus or fixated to the fused anterior and posterior capsular remnants. Capsular bag fixation is most commonly used. One of the advantages of primary IOL implantation is that it facilitates implantation of the IOL in the capsular bag (Case 1). Implantation of an IOL in the capsular bag generally results in excellent long-term centration. Either a one-piece or three-piece IOL can be used for intracapsular IOL implantation. The anterior capsulorhexis should be made only slightly smaller than the diameter of the lens optic to facilitate placement of the haptics into the capsular bag. Primary IOL implantation can also be performed in the ciliary sulcus. If there is adequate capsular support, the haptics of the IOL can be positioned anterior to the capsular ring. If the capsule has been torn or there is zonular dehiscence, it may be necessary to fixate the haptics with sutures or scleral fixation. Only three-piece IOLs with posterior angulation should be used for sulcus fixation because of the risk of inducing the uveitis-glaucoma-hyphema (UGH) syndrome from chaffing of the iris by the haptics of a one-piece IOL. A sulcus fixated IOL can either be left anterior to the capsular bag or captured behind the capsular bag. In optic capture the anterior and posterior leaflets of the capsule are sealed anterior to the optic, except for the area around the optic-haptic junction. This technique prevents migration of lens epithelial cells along the vitreous face. Successful capture can be demonstrated when the lens optic is beyond the posterior capsule and an ellipsoid shape of the posterior continuous curvilinear capsulorhexis (PCCC) is noted (Case 2) [10]. Limitations to this procedure include a PCCC that is too small, leading to posterior capsular tear or a PCCC that is too large and unable to capture the optic [11]. A third option is placing the remnants of the capsular bag in a groove on a specially designed IOL ("bag in the lens" technique) [12]. This involves placing the capsular ring in a groove on the lens that allows the anterior and posterior capsular bag remnants to fuse together, thereby reducing the risk of reproliferating lens material growing into the pupillary space.

Posterior Capsule Management

One of the challenges of pediatric cataract surgery is that if the posterior capsule is left intact posterior capsular opacification (PCO) universally occurs. In some instances preserving the posterior capsule may be indicated, such as in older age groups, history of posterior segment pathology, or ocular inflammation. Since treatment of PCO generally requires a reoperation in young children, a posterior capsulotomy should be created at the time of primary IOL implantation. Various techniques may be used to create a posterior capsulotomy, either with a vitrector or manually. One commonly used approach is to use a vitrector after aspirating lens cortex. The posterior capsule opening should be well centered, concentric, and smaller than the anterior capsulorhexis (4 mm). A central anterior vitrectomy can then be created. A limbal or pars plana approach can be used to create a posterior capsulotomy with a vitrector. The advantage of a limbal approach is that the same incisions used to remove the cataract can be used to perform the posterior capsulotomy and anterior vitrectomy. With the pars plana approach, the location of the entry site should be based on the age of the child. In patients <1 year the incision should be made 2 mm posterior to limbus. In patients 1–4 years the incision should be made 2.5 mm posterior to the limbus, and in patients >4 years the incision should be 3 mm posterior to the limbus [13, 14]. The pars plana approach has the advantage that the IOL is implanted with the posterior capsule intact [15]. However, it has the disadvantage that a pars plana incision has to be created and there are concerns about the long-term safety of this technique.

A posterior capsular opening can also be performed using a manual PCCC technique. Because the posterior lens capsule is 3–5 times thinner than the anterior capsule, a manual PCCC is technically challenging [16]. The use of an ophthalmic viscoelastic device (OVD) is necessary to flatten the capsule while creating a manual PCCC. Some surgeons use the technique of making a small hole in the posterior capsule and injecting OVD to displace the vitreous face posteriorly in order to prevent it from being opened when the posterior capsulotomy is being performed [17]. In addition, by displacing the anterior hyaloid membrane posteriorly, some have hypothesized that this reduces the likelihood that the anterior hyaloid can act as a scaffold for future lens epithelial cell migration [18–20]. Performing a PCCC without a vitrectomy frequently results in opacification of the anterior hyaloid membrane. However, using this approach makes it more difficult to implant the IOL in the capsular bag (Case 1). When implanting an IOL in an eye with a posterior capsulotomy, it is very important to keep the lens flat while injecting it into the capsular bag, since the lens can easily be injected into the posterior segment of the eye through the posterior capsular opening. Once the anterior portion of the lens is in the correct plane the lens can easily be rotated into place using an IOL manipulator.

If the posterior capsule is left intact at the time of cataract surgery, then an in office neodymium:YAG capsulotomy can be performed for cooperative children when the posterior capsule opacifies. In young children, PCO can occur within a few months, but in an older child PCO usually develops 1–2 years after cataract surgery. Multiple YAG laser treatments or even a surgical posterior capsulotomy may be necessary to clear the visual axis [21]. If it is deemed likely that the child will not cooperate with an office YAG capsulotomy, a posterior capsulotomy should

be performed at the time of cataract surgery. While a YAG laser is available in some operating rooms, performing this procedure in the operating room exposes a child to general anesthesia and in most cases the procedure must be performed with the child in a sitting position, which is difficult with an intubated child.

Wound Construction in Primary IOLs

The most common options for the primary wound in pediatric cataract surgery are either a scleral tunnel or a corneal incision. The advantage of a scleral tunnel wound is that there is a lower risk of wound leak and there is no visible corneal scar. However, this technique does require that the conjunctiva be disturbed, thus resulting in more postoperative discomfort and making it more difficult to perform glaucoma procedures in the future. A scleral tunnel is constructed using a beveled ophthalmic blade starting 2–3 mm posterior to the limbus. The initial grove should be the width of the IOL injector that will be used. The tunnel should extend into the cornea, but not enter the anterior chamber. Entry into the anterior chamber is completed using a smaller blade, with the incision size depending on the size of the instrument used to aspirate the lens. The wound is later enlarged for IOL insertion with a keratome blade.

The advantage of a corneal incision is the conjunctiva is not disturbed and iris prolapse is less likely to occur since the wound is more anterior. However, in younger children it can result in a visible corneal scar. An initial small incision is made for cataract removal and vitrectomy and the wound is then enlarged with a keratome for lens insertion (Fig. 13.1). Starting with a small incision for capsulorhexis and lensectomy prior to IOL insertion allows for better anterior chamber fluidics and less anterior chamber collapse.

For either the scleral tunnel or corneal incision, the wound is usually made superiorly so that it will be protected by the upper eyelid. Most pediatric cataract surgeons suture the wound with absorbable polyglactin suture (10–0 for clear corneal incisions, 9–0 for scleral tunneled incisions).

Case 1

A 4-year-old male presented with bilateral congenital cataracts. His medical history was significant for being born at 37 gestational weeks with jaundice and pulmonary edema requiring a 1-month hospitalization. He was diagnosed with bilateral congenital cataracts at age 3 years. The first surgeon who evaluated him did not recommend cataract surgery. The child's parents had not noted a problem with his vision, but did note increased photophobia. There was no family history of congenital cataracts. Slit lamp examination was significant for bilateral lamellar cataracts with best corrected visual acuity of 20/40 OD and 20/60 OS. Due to decreased vision and increased light sensitivity secondary to cataracts, he underwent bilateral cataract surgery, first on the left eye as shown in Fig. 13.1.

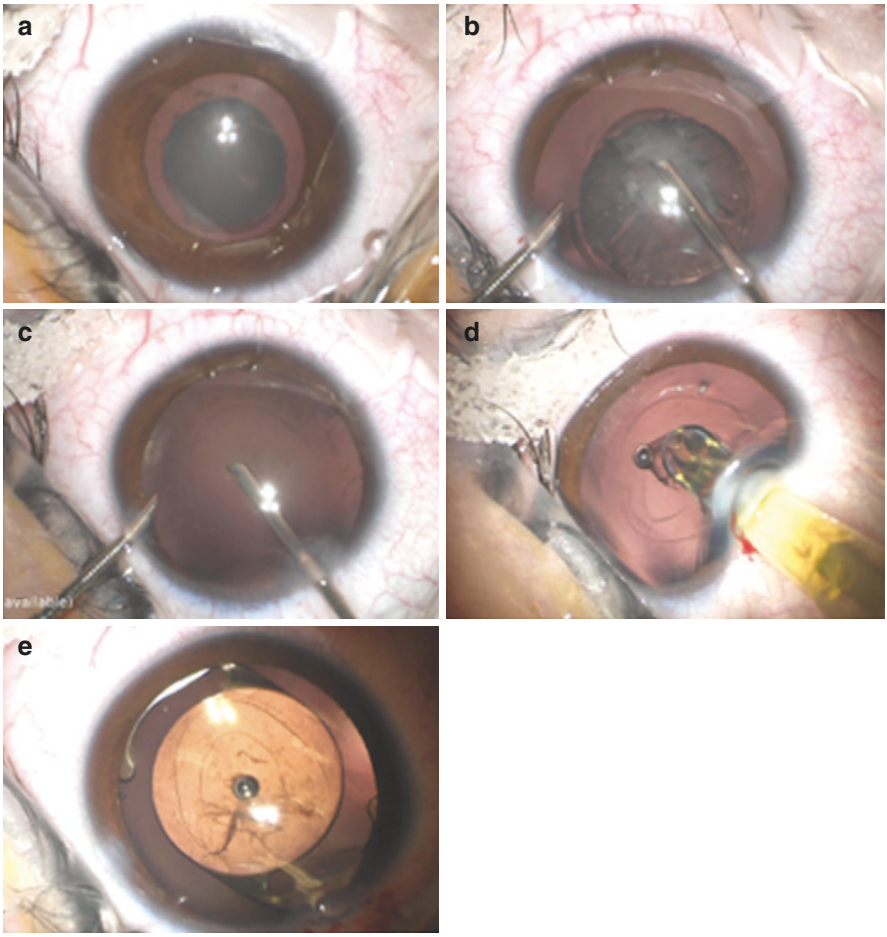

Fig. 13.1 (**a**) Lamellar unilateral cataract of the left eye. (**b**) A 5 mm anterior capsulorhexis has been made. The lens cortex and nucleus are being aspirated with a vitrector using a corneal incision. A Lewicky cannula is being used to maintain the anterior chamber. (**c**) A posterior capsulotomy is created through the corneal incision using the vitrector on shave mode. It is smaller than the anterior capsulotomy. (**d**) The capsular bag has been filled with an OVD, and the one-piece IOL is being injected into the capsular bag after enlarging the corneal incision to 3 mm with a keratome blade. Note the flat delivery of the leading edge of the lens into the capsular bag to ensure that the leading haptic is positioned in the capsular bag inferiorly. (**e**) The IOL is shown after being positioned in the lens capsular bag. The larger anterior capsulotomy and smaller posterior capsulotomy are visible. The wound is then sutured closed with 10.0 absorbable polyglactin suture and the remaining OVD is aspirated with a Simcoe cannula

Comment This case demonstrates primary IOL implantation in a 4-year-old. His age made the likelihood of posterior capsule opacification higher and he was judged to be too young to sit successfully for a postoperative YAG capsulotomy. Therefore, a posterior capsulotomy was created, in this circumstance, using the anterior surgical incision. Wounds were closed using 10–0 absorbable sutures.

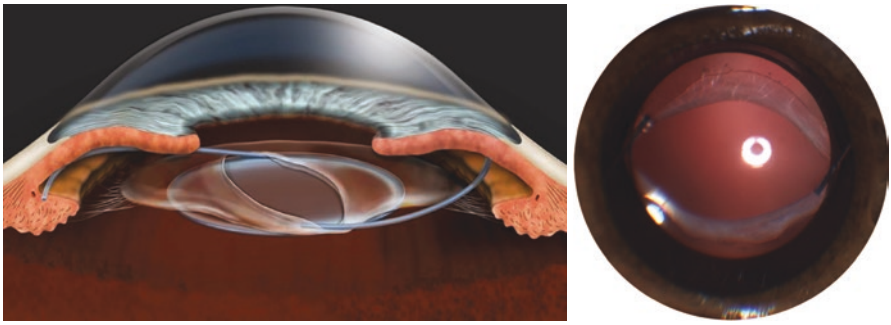

Fig. 13.2 Intraocular lens capture. (Images provided by Stephen Lipsky MD)

Case 2

A 2-year-old male was referred by his pediatrician for right eye drifting over the past 3 months. His family stated that he had a normal birth history and denied any significant medical problems. On exam, he had poor fixation with the right eye and a 20 prism diopter intermittent exotropia. On slit lamp exam a dense lamellar cataract was present in the right eye and the left lens was clear. B-scan of the right eye demonstrated no signs of retinal detachment or stalk associated with persistent fetal vasculature. His family agreed to proceed with cataract removal and IOL placement. Based on his age, a three-piece lens was selected with a target of +4.00 intentional hyperopia.

An anterior manual continuous curvilinear capsulorhexis 5 mm in diameter is created and the cataract is removed in its entirety. A 4 mm posterior capsulotomy is then made concentric to the anterior capsulorhexis. The lens is injected into the lens sulcus and optic carefully pushed behind the anterior and posterior capsule, creating an ellipsoid shape of the capsule (Fig. 13.2).

Comment In this case, a three-piece IOL was selected and optic capture was performed to enhance lens stability. The resulting fusion of the anterior and posterior leaflets of the capsule anterior to the optic prevents migration of lens epithelial cells along the vitreous face. This technique reduces the likelihood of lens reproliferation into the visual axis in this young child.

References

1. Beck AD, Freedman SF, Lynn MJ, Bothun E, Neely DE, Lambert SR. Glaucoma-related adverse events in the Infant Aphakia Treatment Study: 1-year results. Arch Ophthalmol. 2012;130:300–5.
2. Freedman SF, Lynn MJ, Beck AD, et al. Glaucoma-related adverse events in the first 5 years after unilateral cataract removal in the Infant Aphakia Treatment Study. JAMA Ophthalmol. 2015;133:907–14.

3. Birch EE, Stager DR. The critical period for surgical treatment of dense congenital unilateral cataract. Invest Ophthalmol Vis Sci. 1996;37:1532–8.
4. Dave H, Phoenix V, Becker ER, Lambert SR. Simultaneous versus sequential bilateral cataract surgery for infants with congenital cataracts: visual outcomes and economic costs. Arch Ophthalmol. 2010;128:1050–54; Lambert SR. Toxic anterior segment syndrome following pediatric cataract surgery. J AAPOS. 2010;14:381–2.
5. Lambert SR, Lynn M, Drews-Botsch C, et al. A comparison of grating visual acuity, strabismus, and reoperation outcomes among children with aphakia and pseudophakia after unilateral cataract surgery during the first six months of life. J AAPOS. 2001;5(2):70–5.
6. McClatchey SK, Parks MM. Theoretic refractive changes after lens implantation in childhood. Ophthalmology. 1997;104:1744–51.
7. Enyedi LB, et al. Refractive changes after pediatric intraocular lens implantation. Am J Ophthalmol. 1998;126(6):772–81.
8. Crouch ER, Crouch ER, Pressman SH. Prospective analysis of pediatric pseudophakia: myopic shift and postoperative outcomes. J Am Assoc Pediatr Ophthalmol Strabismus. 2002;6(5):277–82.
9. Plager DA, Kipfer H, Sprunger DT, Sondhi N, Neely DE. Refractive change in pediatric pseudophakia: 6-year follow-up. J Cataract Refract Surg. 2002;28(5):810–5.
10. Gimbel HV, DeBroff BM. Posterior capsulorhexis with optic capture: maintaining a clear visual axis after pediatric cataract surgery. J Cataract Refract Surg. 1994;20(6):658–64.
11. Vasavada AR, Trivedi RH, Singh R. Necessity of vitrectomy when optic capture is performed in children older than 5 years. J Cataract Refract Surg. 2001;27:1185–93.
12. Vasavada AR, Praveen MR, Tassignon M-J, Shah SK, Vasavada VA, Vasavada VA, et al. Posterior capsule management in congenital cataract surgery. J Cataract Refract Surg. 2011;37(1):173–93. https://doi.org/10.1016/j.jcrs.2010.10.036.
13. Maguire AM, Trese MT. Lens-sparing vitreoretinal surgery in infants. Arch Ophthalmol. 1992;110:284–6.
14. Aiello AL, Tran VT, Rao NA. Postnatal development of the ciliary body and pars plana; a morphometric study in childhood. Arch Ophthalmol. 1992;110:802–5.
15. Trivedi RH, Wilson ME. Posterior capsulotomy and anterior vitrectomy for the management of pediatric cataracts. In: Wilson ME, Trivedi RH, Pandey SK, editors. Pediatric cataract surgery: techniques, complications, and management. Philadelphia: Lippincott, Williams and Wilkins; 2005. p. 83–92.
16. Krag S, Andreassen TT. Mechanical properties of the human posterior lens capsule. Invest Ophthalmol Vis Sci. 2003; 44:691–96. Available at: http://www.iovs.org/cgi/reprint/44/2/691. Accessed 3 Aug 2010.
17. Van Looveren J, Vael A, Ideler N, Sillen H, Mathysen D, Tassignon M-J. Influence of the vitreolenticular interface in pediatric cataract surgery. J Cataract Refract Surg. 2018;44(10):1203–10. https://doi.org/10.1016/j.jcrs.2018.06.052.
18. Morgan KS, Karcioglu ZA. Secondary cataracts in infants after lensectomies. J Pediatr Ophthalmol Strabismus. 1987;24:45–8.
19. Nishi O. Fibrinous membrane formation on the posterior chamber lens during the early postoperative period. J Cataract Refract Surg. 1988;14:73–7.
20. Jones NP, McLeod D, Boulton ME. Massive proliferation of lens epithelial remnants after Nd-YAG laser capsulotomy. Br J Ophthalmol. 1995;79:261–3.
21. Elkin ZP, Piluek WJ, Fredrick DR. Revisiting secondary capsulotomy for posterior capsule management in pediatric cataract surgery. J Am Assoc Pediatr Ophthalmol Strabismus. 2016;20(6):506–10. https://doi.org/10.1016/j.jaapos.2016.06.011.