Chapter 11
Pediatric Aphakic Contact Lenses

James Hoekel

Uncorrected aphakia is as apt as the original lens opacity to limit visual potential. There exist situations where the best and safest option for a patient is to not place an intraocular lens (IOL). In these circumstances, aphakic contact lens fitting after lensectomy can be the preferred means of optical correction. With contact lens correction of aphakia, the image projected on the retina is of normal size and lacks the aberrations and distortion seen with high plus aphakic glasses. Additionally, high plus spectacles can induce a prismatic effect, decrease peripheral vision, and cause anisometropic diplopia. The weight and the thickness of the lenses can render aphakic glasses challenging for babies or children with flat nasal bridges to wear comfortably. With the advent of more materials, better education, and scientific studies, the outcomes with contact lenses are more predictable than a few decades prior. Another advantage of aphakic contact lenses is ease of replacement, especially when needing to adjust the power. Especially in a young eye with rapid axial length elongation, contact lens power adjustments can be made far more readily than new aphakic spectacles. Aphakic rehabilitation requires that the physician, the caregiver, and the patient work together to overcome hurdles leading to amblyopia. The ultimate goal is to provide the child with usable vision and prevent or limit amblyopia by eliminating sight-threatening blur.

J. Hoekel (✉)
St. Louis Children's Hospital Eye Center, Department of Ophthalmology and Visual Sciences, Washington University School of Medicine, St. Louis, MO, USA
e-mail: Hoekel@wustl.edu

C. L. Kraus (ed.), *Pediatric Cataract Surgery and IOL Implantation*,
https://doi.org/10.1007/978-3-030-38938-3_11

Fitting Aphakic Contact Lenses

Exam

The fitting process begins with a conversation between the eye care team and the child's family. Just as the surgical team discusses the risks, benefits, and alternatives to performing cataract surgery, the same discussion is necessary before fitting a child with a contact lens. The first decisions will be daily wear versus extended wear and soft lens versus rigid gas permeable (RGP). The parents' own history with contact lens wear may influence the choice for their child. For instance, if a parent is an RGP wearer, then they may be more comfortable with their child being fit with an RGP contact lens.

The timing of the initial fit is up to the team involved in caring for the child. The currently available literature supports fitting the child 1–27 days after surgery. In the author's practice, there are multiple surgeons with individual preferences for the timing of the initial fit. Fitting the child as early as possible is advisable, but can be complicated by the drops and ointment used during the postoperative period. The use of steroid antibiotic ointment is not compatible with contact lens wear, so it is recommended to use only steroid antibiotic drop after surgery or wait until the ointment is finished. The commonly prescribed prednisolone acetate is a suspension that can ruin the surface of silicone elastomer lenses.

Determining Diameter, Base Curve, and Power

The next step to proper fitting is determining necessary diameter, power, and base curve. If the infant is quite young, these values may be difficult to acquire. Many contact lens fitters utilize keratometry values, corneal diameter, and pachymetry from the examination at the time of the lensectomy. While this information is certainly useful, it is possible to achieve a good contact lens fit and prescription without any prior information. In young infants, the cornea tends to be steep, especially in eyes with persistent fetal vasculature (PFV).

At the fitting appointment, this author frequently has several new contact lenses for diagnostic purposes (Fig. 11.1). By having multiple lens choices, one can typically improve the likelihood of achieving an ideal fit. For use in infancy, many providers start with a SilSoft® Super Plus, which is a silicone elastomer lens developed by Bausch & Lomb. This silicone contact lens is made from a rubberlike material that is highly oxygen permeable and has been utilized for extended wear for over three decades since being introduced by Dow Corning Ophthalmics in 1983. The SilSoft® Super Plus comes in three base curves (7.5, 7.7, 7.9) in the 11.3 diameter. The power choices are +23.00 to +32.00 in three diopter steps. There is a larger diameter SilSoft® that has a 12.5 mm diameter, but it is only available in power choices from +12.00 to +20.00. The initial diameter is chosen based on the corneal

Fig. 11.1 Examples of aphakic contact lenses

diameter or what many surgeons refer to as the "white to white" measurement. In soft lens fitting, utilizing a larger diameter provides increased stability, but the lens becomes more difficult to insert and remove. If the edge of the soft contact lens does not completely cover the limbus, then the child may experience redness, discomfort, lens awareness, and punctate keratopathy.

The initial contact lens power is determined based on retinoscopic findings and then prescribed near addition. This author typically refracts twice in the fitting appointment to confirm correct power selection. The cycloplegic refraction is performed utilizing loose lenses and then the child is over-refracted with the contact lens in place. This adds time to the fitting appointment but it also serves as confirmation of the proper lens power.

Contact Lens Fit

The contact lens should move some, but not too much. It should conform to the cornea, but if too tight it can cause limbal impingement and if too loose it is uncomfortable and fails to provide sharp vision. Ideally, the lens should have 0.5 mm of movement and be easy to move with the finger. If at first the lens moves too much, allow the patient to wait 15 minutes before changing to a different lens, as the lens tightens after the initial tearing subsides. A child rubbing excessively is frequently displaying signs of poor comfort or fit.

At birth, the horizontal corneal diameter is about 10 mm and increases in the first 18 months of life [1]. As the cornea becomes flatter, the initial CTL may become too steep and have bubbles or tighten excessively and "pop off" of the eye. When this occurs and a SilSoft® lens is still desired, the 7.5 initial base curve should be changed to a 7.7 base curve. Small diameter corneas, such as in persistent fetal vasculature or microcornea/microphthalmia, need the smallest lens diameter available or a lens that is custom manufactured to an overall diameter between 11 and 12 mm.

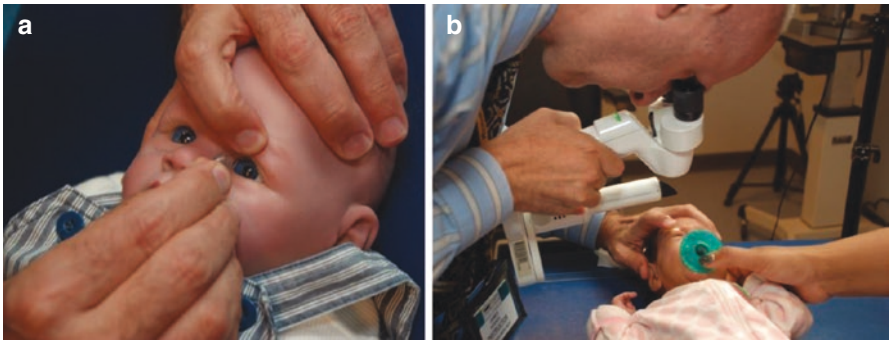

Fig. 11.2 (**a**) Insertion of a SilSoft contact lens. (**b**) Portable slit lamp exam for centration and fit

Case 1

AH was diagnosed with a congenital cataract on day of life one. Lensectomy without IOL implantation was performed at 4 weeks of age and contact lens fitting was scheduled 1 week postoperatively. The child's keratometry values were 48.75/49.00 in her aphakic eye. Her axial length was 17.1 mm. Her refraction was +21.50. This vertexes to +29.12 in contact lens power and 3.00 diopters were added to focus the child for near distances. A SilSoft +32.00 contact lens was chosen. Initially, this lens was a little flat for the steep infant cornea, but it was selected due to the ease of insertion (Fig. 11.2), good centration, and clear optics. The lens was dispensed on a 30-day extended wear basis. Since this was her first contact lens, the author evaluated the child at 1 week to ensure no extended wear complications occurred. A multipurpose contact lens solution was provided for cleaning and storage and also in case of contact lens coming out of the eye.

Comment This case describes the typical approach to an aphakic infant. A common frustration expressed by parents is when the lens is seen to float off of the cornea. In this case, the parent would diligently look and share with the office how many times per month the lens moved out of position or came off the eye. This information is useful for determining need to change lens parameters. The author recommends a 1-week follow-up to measure fixation and perform portable slit lamp biomicroscopy and over-refraction with trial lenses. The author also removes the lens to look carefully at the cornea, limbus, and anterior chamber, measures IOP, and inspects the lens under the microscope. If the lens is too cloudy or has already accumulated deposits, then a new contact lens is inserted. Multiple studies have established that there are inherent risks with contact lens wear, especially on an extended wear basis, but with diligence and good fitting lenses, infantile wear is quite safe [2–10].

Selection of Aphakic Contact Lenses

When the eye is open, the cornea receives oxygen from the atmosphere, the limbal vasculature, and the aqueous humor. Contact lenses sit on the eye, obstructing the complete transmission of oxygen to the eye. Each lens material has intrinsic oxygen permeability (Dk). The contact lens manufacturers publish the Dk for each contact lens and when fitting an aphakic child, the thickness of the lens should also be taken into consideration. This measurement is called critical oxygen transmissibility (Dk/t), with 't' being the thickness of the lens. The Dk/t of the lens should be 125×10^{-9} for extended wear and 35×10^{-9} for daily wear [11]. The published oxygen permeability of silicone elastomer lenses is $340 \times 10^{-11,}$ but there is some debate as the reports of oxygen transmissibility through thick lenses vary in the literature [11]. Currently with RGPs, there are a number of lenses with known Dk values greater than 100. Ophthalmologic and optometric research have established how much oxygen is required for safe contact lens wear and how much oxygen permeability is tolerable before one may experience pathologic changes in corneal morphology [12].

Custom Contact Lenses

Custom contact lenses are an indispensable tool, freeing the provider from being limited by only a few base curves and a couple diameters. The ability to design, order, and dispense a contact lens that will fit a child exactly confers a higher success rate of both comfort and visual clarity. In the early days of contact lenses, poly-2-hydroxyethyl methacrylate (HEMA) could be made in a variety of specifications, but the lenses were limited in their use in high plus pediatric correction due to reduced oxygen permeability. The advent of silicone hydrogels introduced a lens that delivered greater oxygen permeability with less fragility of silicone elastomer. Silicone hydrogels are different than silicone elastomer lenses.

One such silicone hydrogel material (Definitive®) can be lathe cut by manufacturers of specialty soft contact lenses. Currently there are several major contact lens manufacturers that have higher Dk silicone hydrogels, but at the time of this publication the lens powers are not available in high plus for aphakia. The Definitive® material typically provides robust oxygen permeability, good comfort, and quality optics (Dk/t up to 60). A contact lens lab may lathe this material into the curve, power, and diameter desired to provide an ideal fit. The ability to manufacture this in high plus with a variety of diameters and base curves gives the pediatric specialist a myriad of choices. Unfortunately, these lenses are not easy to insert in an infant, but should be considered if non-custom lenses are too tight, too loose, or coat and film too quickly. Significant chair time may be necessary to get an ideal fit as the stiffness of this lens renders it challenging to achieve this on the first try.

Some manufacturers will have a guaranteed fit period in which exchanges and reorders may be included, but each custom lens manufacturer has their own unique fitting policies. This lens has FDA approval for daily wear, but many providers prescribe 7-day 6-night off-label, extended wear.

When fitting a child with a custom contact lens look for a fit that does not compress the apex of the cornea. If a lens fit is too steep, it can create central corneal issues, peripheral tightening, and vascularization. While too steep of lens typically leaves a small space over the apex of the cornea, it is too tight in the periphery or mid-periphery causing discomfort, redness, limbal impingement, or improper tear exchange. Too loose of contact lens will display excessive movement and migrate temporally or superiorly. The silicone hydrogel must be fit appropriately; otherwise mechanical complications may arise such as contact lens-related papillary conjunctivitis and superior epithelial splits [11, 13–21]. Some practitioners utilize Fluresoft to evaluate contact lens staining patterns, although it can stain the lens. It is possible to evaluate limbal coverage, soft lens movement, and pooling or bearing with a portable slit lamp or handheld Burton lamp. Follow-up slit lamp examinations during the fitting or refitting may alert the provider to the need to replace on a more frequent basis especially in the setting of papillary conjunctivitis, corneal staining, microcysts, mucin balls, edema or polymegathism.

Case 2

MB suffered from bilateral congenital cataracts. She underwent lensectomy and vitrectomy of her right eye at 6 weeks of age. The left eye underwent the same successful lensectomy and vitrectomy at 7 weeks. She did well in the immediate postoperative period and, at 24 months of life, underwent implantation of an MA60 IOL in her right eye. At 25 months of life an MA60 IOL was implanted in her left eye.

Postoperative day one and week one visits were unremarkable. At the 1-month post-op visit, the left IOL appeared subluxed below the visual axis. The child underwent an examination under anesthesia with attempt at lens repositioning, but this was not successful as there was not enough capsule to support an IOL so she was referred for aphakic contact lens fitting.

As a 25-month-old infant her corneal diameter was 10.5 mm, her keratometry values in the aphakic eye were 42.62/43.00, and her axial length was 20.79. Her refraction at this time was +14.50. At this time Ciba made a custom silicone hydrogel lens called O2 Optix. This silicone hydrogel innovation had a Dk/t of 117 at −3.00. The patient was fit with a +18.50 contact lens in the 8.00 base curve radius (BCR) with a 13.2 overall diameter (OAD). Over the following 6 months there were no significant changes in refractive power but the lens became too small and failed to provide stable corneal coverage. At 31 months of life she was refit into the 8.4 BCR with a 14.0 OAD. This larger lens had better centration and provided less movement off her eye.

Ciba vision discontinued manufacturing her contact lens when she was around 50 months of age. The child had enjoyed silicone hydrogel's comfort and

replaceability since the lens came in a 4 pack; we wanted to continue in that same modality. Xcel contact lenses made the same parameter lens in a multipack utilizing Definitive® silicone hydrogel material. Over the following 6 years her visual acuity in the contact lens has been equal to the visual acuity in her pseudophakic eye although over time this eye has been become dramatically more myopic, whereas the aphakic eye has minimally changed refraction. As the child grew older, insertion became much easier and the child switched from extended wear to daily wear.

Comment This case reviews the process of initial contact lens selection and the need for reevaluation in the care of children with aphakic contact lenses. The author selected a silicone hydrogel lens for this unilaterally aphakic child as the Dk was 175×10^{-9} and the lens came in multipack options. This case further highlights how eye growth can lead to changes in type and parameters of contact lenses. In addition, factors such as manufacturer availability can have an impact on lens selection. It is encouraging to note that in this case of bilateral cataracts, the aphakic and pseudophakic eyes developed equal visual acuity.

Gas Permeable Lenses (Rigid Gas Permeable)

Gas permeable (GP) lenses for pediatric aphakia have advantages and disadvantages (Table 11.1). They are useful for the refractive treatment of traumatic aphakia and post pediatric penetrating keratoplasty. Each manufacturer has their own fitting guidelines and typically provides consultation lines to assist in achieving an ideal fit. Sitting for corneal topography is helpful when the child is old enough to do so.

The high plus GP has increased thickness; in addition, because its center of gravity is more anterior, its biggest challenge is centration. Many providers will utilize a lenticular design or a corneoscleral design in order to achieve stability.

Table 11.1 Comparison of Soft versus Gas Permeable contact lenses

Soft contact lens	Rigid gas permeable
Advantages	*Advantages*
Good initial comfort	Can mask or correct corneal astigmatism
Relatively uncomplicated fitting	Can be easy to insert and remove
Reduced provider time	Durable and long lasting
Less parental apprehension	Can be manufactured for high oxygen permeability
Easily replaceable	
Disadvantages	*Disadvantages*
Microbial keratitis	May have parental apprehension
Potential hypoxia concerns	Injection and redness
Relatively sparse approval for extended wear in high powers	Keratopathy or abrasion
	Initial discomfort
	Increased provider time (chair time)
	Relatively few choices in hyper Dk material

If the lens decenters inferiorly, this can cause corneal staining, contact lens discomfort, conjunctival injection, and unstable acuity. If the high plus lens is manufactured with a minus lenticular, then this may assist the upper lid in holding the contact lens in position.

Currently, there are numerous hyper Dk lenses that provide adequate oxygen permeability and safe extended wear. For the successful fitting of an infant, it is recommended to use a diagnostic fitting set. Often these fitting sets are loaned from the lab of choice or purchased from the manufacturer, distributor, or contact lens supplier. The initial lens may be chosen based upon the age/table/previous keratometry value of fitting experience. It is most important to be precise in base curve choice as to not create irritation and corneal harm. For a neonate the initial base curve of choice will be 7.00 mm with a +29.00 as a diagnostic lens. After allowing the contact lens to settle the power can be checked with an over-refraction, fluorescein staining can be evaluated to see if the lens is bearing or vaulting, and the overall diameter of the lens can be assessed to determine its stability and movement. At this stage, one should also evaluate the GP for edge lift and centration.

Caring and Wearing Aphakic Lenses

Insertion and Removal

Many parents will initially struggle with the insertion and removal of pediatric aphakic contact lenses. There are a number of contact lens providers that will insert the lenses for the parents on a weekly or monthly basis, although this practice is time intensive for both the family and provider. This author always tries to identify those families that struggle with insertion and provide "anytime" service as most children can have their lens inserted by an experienced practitioner rather quickly. Lie the child flat with a staff member holding the head and parent holding the hands of the child (Fig. 11.3). Right-handed providers may find it easier to stand on the child's right side in order to insert. The size of the lens and the amount of squeezing and the depth of the orbit and the vertical distance between the lid margins all factor into the challenges and ease of insertion.

Upkeep and Wear

Silicone elastomer lenses like the SilSoft® are prone to film development due to the proteinaceous nature of tears. This renders it necessary to replace the lens anywhere from monthly to every 6 months. Handling of this lens requires diligent and careful precautions. The use of soaps, lotions, creams, ointments, perfumes, and deodorants may cause irritation or damage to the lens. Customer service representatives

Fig. 11.3 Insertion of contact lens in a young infant by a right-handed author

frequently recommend non-scented glycerin soaps to avoid contamination and filming of the lens. Many hospital-based offices will have antibacterial soaps with lotion additives that may film and ruin the surface of the lens. Parents should be informed of the need to rinse hands thoroughly before handling the lens to avoid film buildup. Over the last two decades, contact lens solutions have improved with additives that clean the lens better and help keep the surface moist. However, these solutions can

interact poorly with silicone and silicone hydrogel lenses. This author recommends the use of BioTrue® for cleaning and storage but there are a large number of multipurpose solutions to choose from.

Complications

There are reassuringly few complications associated with SilSoft® lenses although the greatest concern is microbial keratitis and corneal ulcers. The incidence of microbial keratitis in extended wear is variable in infants and toddlers [9]. The rate in infants may be lower due to the robust tear film and diligence of newborn parents. Many fitters worry that the higher rate of community-acquired conjunctivitis in this young population places children at higher risk, but a well-fitting lens is the best protection.

Central scarring, neovascularization, and central or peripheral infiltrates are also devastating adverse events for contact lens wearers. There are also minor and temporary complications such as keratopathy, edema, injection, and lid swelling. However, the most frequent complication is lens loss. Compliance is variable in children and when contact lens compliance is poor, the child is certainly more at risk for underuse or misuse. Many of these contact lenses are quite expensive and some insurers will not cover their cost even when medically indicated. Some children will become intolerant of contact lenses during the 18–48-month age even in the setting of an ideal fit and good tear surface.

Continuous wear lenses (formerly referred to as extended wear) require vigilance as wear on an extended wear basis places a child at risk of hypoxic-related events including edema, infection, neovascularization, scarring, keratitis, endothelial polymegathism, pleomorphism, epithelial microcysts, and epithelial thinning [22]. When selecting such a lens, the goal is to have a lens that provides enough oxygen to the cornea when the child is awake and especially when the eyes are closed during sleep. It has been exciting to watch the contact lens industry improve oxygen transmission through improved materials.

The risk of potential harm to a child's cornea by a contact lens is outweighed by the visually devastating condition of uncorrected aphakia. Most contact lens experts advocate that extended wear is far riskier to corneal health than daily wear, but in a young child who struggles with insertion, it frequently becomes more practical to leave the lens in place. As the SilSoft® and some hyperDk GP materials may see the lens surface degrade with excessive handling, it may be beneficial to use extended wear. The alternative option is the use of daily wear. Like many duties of the parent, daily insertion and removal of a lens is initially a chore that is met with mixed emotions, but eventually becomes a routine and less of a hassle. It is with great hope that polymer chemistry and improved engineering will create more lens choices with thinner centers, multipack options, increased wettability, and increased oxygen transmission to deliver the best visual treatments for those that need it at the most critical time in visual development.

References

1. Abbasi RU, Abu-Zayyad T, Amann JF, et al. Measurement of the flux of ultrahigh energy cosmic rays from monocular observations by the high resolution fly's eye experiment. Phys Rev Lett. 2004;92:151101.
2. Cromelin CH, Drews-Botsch C, Russell B, Lambert SR, Infant Aphakia Treatment Study Group. Association of contact lens adherence with visual outcome in the Infant Aphakia Treatment Study: a secondary analysis of a randomized clinical trial. JAMA Ophthalmol. 2018;136:279–85.
3. Bendoriene J. Therapeutic use of silicone hydrogel contact lenses in children. Contact Lens Assoc Ophthalmol. 2006;32:104–8.
4. Lindsay RG, Chi JT. Contact lens management of infantile aphakia. Clin Exp Optom. 2010;93:3–14.
5. Matsuda M, Inaba M, Suda T, MacRae SM. Corneal endothelial changes associated with aphakic extended contact lens wear. Arch Ophthalmol. 1988;106:70–2.
6. Glynn RJ, Schein OD, Seddon JM, et al. The incidence of ulcerative keratitis among aphakic contact lens wearers in New England. Arch Ophthalmol. 1991;109:104–7.
7. de Brabander J, Kok JH, Nuijts RM, Wenniger-Prick LJ. A practical approach to and long-term results of fitting silicone contact lenses in aphakic children after congenital cataract. CLAO J. 2002;28:31–5.
8. Russell B, Ward MA, Lynn M, Dubois L, Lambert SR, Infant Aphakia Treatment Study G. The infant aphakia treatment study contact lens experience: one-year outcomes. Eye Contact Lens. 2012;38:234–9.
9. Lambert SR, Kraker RT, Pineles SL, et al. Contact lens correction of aphakia in children: a report by the American Academy of Ophthalmology. Ophthalmology. 2018;125:1452–8.
10. Chen YC, Hu AC, Rosenbaum A, Spooner S, Weissman BA. Long-term results of early contact lens use in pediatric unilateral aphakia. Eye Contact Lens. 2010;36:19–25.
11. Fonn D, Bruce AS. A review of the Holden-Mertz criteria for critical oxygen transmission. Eye Contact Lens. 2005;31:247–51.
12. Harvitt DM, Bonanno JA. Re-evaluation of the oxygen diffusion model for predicting minimum contact lens Dk/t values needed to avoid corneal anoxia. Optom Vis Sci. 1999;76:712–9.
13. Carnt NA, Evans VE, Naduvilath TJ, et al. Contact lens-related adverse events and the silicone hydrogel lenses and daily wear care system used. Arch Ophthalmol. 2009;127:1616–23.
14. Donshik P, Long B, Dillehay SM, et al. Inflammatory and mechanical complications associated with 3 years of up to 30 nights of continuous wear of lotrafilcon A silicone hydrogel lenses. Eye Contact Lens. 2007;33:191–5.
15. Dumbleton K. Adverse events with silicone hydrogel continuous wear. Cont Lens Anterior Eye. 2002;25:137–46.
16. Dumbleton K. Noninflammatory silicone hydrogel contact lens complications. Eye Contact Lens. 2003;29:S186–9; discussion S90–1, S92–4.
17. Holden BA, Stephenson A, Stretton S, et al. Superior epithelial arcuate lesions with soft contact lens wear. Optom Vis Sci. 2001;78:9–12.
18. O'Hare N, Stapleton F, Naduvilath T, Jalbert I, Sweeney DF, Holden BA. Interaction between the contact lens and the ocular surface in the etiology of superior epithelial arcuate lesions. Adv Exp Med Biol. 2002;506:973–80.
19. Sankaridurg P, Chen X, Naduvilath T, et al. Adverse events during 2 years of daily wear of silicone hydrogels in children. Optom Vis Sci. 2013;90:961–9.
20. Sankaridurg PR, Sweeney DF, Sharma S, et al. Adverse events with extended wear of disposable hydrogels: results for the first 13 months of lens wear. Ophthalmology. 1999;106:1671–80.
21. Santodomingo-Rubido J, Wolffsohn JS, Gilmartin B. Adverse events and discontinuations during 18 months of silicone hydrogel contact lens wear. Eye Contact Lens. 2007;33:288–92.
22. Zimmerman AB, Nixon AD, Rueff EM. Contact lens associated microbial keratitis: practical considerations for the optometrist. Clin Optom (Auckl). 2016;8:1–12.