Management of Contact Lenses and Visual Development in Pediatric Aphakia

Tomris Şengör*, Tuğba Gençağa Atakan**

*Private Practice, İstanbul, Türkiye
**University of Health Sciences Türkiye, Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital, Clinic of Eye Ophthalmology, İstanbul, Türkiye

Abstract

Congenital cataract is among the main causes of treatable vision loss in childhood. The first weeks and months of life are a critical time for the development of vision. Therefore, early cataract surgery and effective multifaceted treatment of the resulting aphakia in the early stages of life are of great value for the management of vision development. Among the treatment models, contact lenses (CL) have an important place in infancy and early childhood up to the age of 2 years. Although good visual gains were not considered very likely, especially in unilateral aphakia, important steps have been taken in the treatment of pediatric aphakia thanks to the surgical techniques developed over time and the increasing experience with optical correction systems, especially CLs. This review examines current developments in the types of CL used in pediatric aphakia, their application features, comparison with other optical systems, the features of amblyopia treatment in the presence of CL, and the results obtained with family compliance to CL wear and occlusion therapy in the light of existing studies.

Keywords: Congenital cataract, pediatric aphakia, contact lens, visual rehabilitation, persistent fetal vasculature

Cite this article as: Şengör T, Gençağa Atakan T. Management of Contact Lenses and Visual Development in Pediatric Aphakia. Turk J Ophthalmol 2024;54:90-102

Address for Correspondence: Tomris Şengör, Private Practice, İstanbul, Türkiye
E-mail: tomris.sengor@gmail.com **ORCID-ID:** orcid.org/0000-0002-9436-5582
Received: 30.03.2023 **Accepted:** 28.11.2023

DOI: 10.4274/tjo.galenos.2023.56252

Introduction

Congenital cataract (CC) is rare worldwide (2.2-13.6/10,000 births) but is one of the leading causes of vision loss in children.[1,2] It can be bilateral or unilateral and can be associated with systemic diseases or congenital abnormalities of the eye such as persistent fetal vasculature (PFV).[3] Aphakia resulting from penetrating eye injuries, which are fairly common in the pediatric age group, often leads to treatment challenges because of the accompanying irregular astigmatism.[4,5,6]

Cataract surgery should be performed as early as possible, as the presence of dense, vision-impairing cataract in the neonatal period and infancy causes amblyopia due to the lack of stimulation.[7] On the other hand, especially in unilateral cataract, the high anisometropia that occurs after surgery carries the risk of amblyopia and secondary strabismus.[8,9] To promote visual development, it is important to provide appropriate optical correction as soon as possible following surgery, implement effective patching treatment, and perform regular follow-up for changes that occur in the growing eye, as well as potential complications.[10]

Glasses, contact lenses (CL), and intraocular lenses (IOL) are options that can be selected for the optical rehabilitation of aphakia in infancy. CLs are one of the most suitable treatment tools because they eliminate aniseikonia, can be used immediately after surgery, can be modified according to the changing refractive power of the eye of the growing child, are available in all dioptric powers, and are low-risk and highly effective.[11,12]

Historically, a good visual gain was considered impossible 40-50 years ago, especially in unilateral CC.[13] With increasing knowledge about the development of the optical system and developments in CL technology, it has been shown that visual acuity (VA) can be improved in unilateral infantile cataract through early surgery, successful CL fitting, and effective patching, without leading to permanent and deep amblyopia.[7,14]

CL fitting and the management of vision development in

pediatric aphakia is one of the most challenging and unique areas of study and includes many components. In this review, the types of CL used in pediatric aphakia, their characteristics, comparison with other optical systems, the features of patching treatment for amblyopia in the presence of CLs, and the results obtained with family adherence to CL wear and patching therapy are examined in the light of existing studies.

Non-contact Lenses Optical Options

Glasses are optical devices that are often preferred for visual rehabilitation in bilateral aphakia because they provide visual improvement comparable to other optical options and are easy to use and obtain.[15] However, high-diopter (D) aphakic glasses are quite heavy and difficult to apply to the infant face. In addition, spectacle lenses have the effect of increasing the image size and narrowing the visual field, which can cause difficulties in children's adaptation to the real world. In unilateral aphakia, they may not be a successful treatment option due to the anisometropia resulting from the high dioptric difference between the two eyes.[10,11]

IOL implantation is a current treatment method with a growing area of use because of certain important advantages such as providing immediate optical correction and not requiring parent or child adherence. However, refractive predictability is low due to the rapid increase in axial length and changes in the corneal curvature that occur in the first two years of life. They may also increase the need for additional intraocular surgeries because of risks such as fibrin reaction, posterior capsule fibrosis, and VA opacification.[7,10] In recent years, comparing CLs with IOLs for the treatment of unilateral or bilateral infantile aphakia in terms of VA and complications has been one of the leading research topics.[7,15]

A meta-analysis study by Chen et al.[16] suggested that VA was better in eyes that underwent primary IOL implantation compared to those with CLs, while there was no increase in risk of complications. However, many previous studies on the subject (summarized in Table 1) demonstrated no difference in VA between high-compliance CL use and IOL implantation, while IOLs were associated with greater differences in change in axial length and astigmatism and higher prevalence of adverse events and risk of reoperation.[18,19,20,22,23,28,29] The results of the studies indicated that CL wear is more advantageous in infancy, IOL implantation is safer after 2 years of age, and secondary IOL surgery at later ages will result in less refractive error.[17,18,19,20,21,22,23,24,25,26,27,28,29]

Table 1. Comparative studies of CLs and IOLs in pediatric aphakia

Authors	Year	Study	Number of patients/ eyes	Follow-up (years)	Outcomes	Comments
Plager et al.[17]	2002	Comparison of complications in CC patients who received an IOL or were left aphakic	Group 1: 13 (15 eyes), surgery at age <6 months, IOL implanted Group 2: 16 (16 eyes), surgery at age >10 months, IOL implanted Group 3: 33 (33 eyes) left aphakic	1	Group 1: 86% surgery for secondary opacification Group 2: No opacification Group 3: 12% surgery for opacification	Early IOL implantation during infancy was associated with increased complications
Birch et al.[18]	2005	Prospective evaluation of VA in infants with unilateral CC who received a primary IOL, were left aphakic, and underwent secondary IOL implantation	Primary IOL implantation: 5 Good-to-excellent CL compliance: 36 Moderate-to-poor CL compliance: 11	4	Mean VA: 20/54 with primary IOL 20/50 with good-excellent CL compliance 20/135 with moderate-poor CL compliance	VA outcome with IOL placement was similar to that in the high CL compliance group but better than in the low CL compliance group
Autrata et al.[19]	2005	Evaluation of VA, reoperation, and ocular development in unilateral CC patients that underwent IOL implantation or were left aphakic	Primary IOL: 18 Received CL: 23	5	0.33 logMAR in IOL group 0.39 logMAR in CL group Reoperation: 78% in IOL; 35% in CL	VA outcomes were similar with IOL and CL, but the need for reoperation was greater in the IOL group
Infant Aphakia Treatment Study Group et al.[20]	2010	VA and complications were evaluated in patients with CL or IOL implantation	114 (57 CL + 57 IOL)	1	VA: 0.80 in the CL group, 0.97 in the IOL group. Reoperation: 12% in CL, 63% in IOL	There was no difference in terms of VA, while the risk of reoperation was higher in the IOL group
Lambert et al.[21]	2012	Axial lengths were compared between unilateral CC patients who received CL or IOL	114 (57 CL + 57 IOL)	1	Axial length changed 0.17 mm in the CL group and 0.24 in the IOL group. Eyes with cataract were 0.6 mm shorter than fellow eyes	Axial length was found to be higher in the IOL group than in the aphakic group

Table 1. Continued

Authors	Year	Study	Number of patients/ eyes	Follow-up (years)	Outcomes	Comments
Magli et al.[22]	2013	Long-term VA and adverse effects were evaluated in bilateral CC patients who underwent primary IOL and secondary IOL implantation	66 (30 IOL + 36 CL)	10	In the primary IOL group, VA at 79 months was 0.53; in the group who underwent secondary IOL implantation after 32 months of CL use, VA at 109 months was 0.54	VA and adverse effects were similar in the primary and secondary IOL groups, but myopic shift was greater in the primary IOL group
Infant Aphakia Treatment Study Group et al.[23]	2014	VA outcomes were compared in infants who underwent vision rehabilitation with CL or primary IOL	114 (57 CL + 57 IOL)	5	Mean VA in both groups: 0.9 logMAR. Postoperative adverse events: 56% in the CL group, 81% in the IOL group. Reoperation: 21% in the CL group and 72% in the IOL group	While there was no difference between the two groups in terms of VA, the need for reoperation was higher in the IOL group
Wall et al.[24]	2014	Surgical factors associated with postoperative astigmatism were examined in the IOL and CL groups	114 (57 CL + 57 IOL)	1	Mean astigmatism changed from 1.92 to 1.62 D in the CL group and from 2.00 to 2.09 D in the IOL group	There is a significant decrease in corneal astigmatism in the CL group compared to the IOL group No other surgical factor had a significant effect
Kruger et al.[25]	2015	Treatment costs were evaluated in the IOL and CL groups	114 (57 CL + 57 IOL)	5	At 5 years, need for at least one reoperation: 21% in the CL group and 72% in the IOL group	IOL implantation was found to be 7% more costly than CL wear
Solebo et al.[26]	2018	Prospective evaluation of outcomes in patients who received a primary IOL before the age of 2 years	102 bilateral and 56 unilateral CC; 88 received an IOL (50 bilateral) and 70 received CL/glasses (52 bilateral)	5	VA was 0.34 logMAR in bilateral and 0.70 logMAR in unilateral patients. Primary IOL implantation increased the risk of reoperation 5-fold in the bilateral and 20-fold in the unilateral cataract group	VA was similar in both groups but there were more complications in the IOL group
Plager et al.[27]	2020	10-year adverse effects, complications, and reoperation were examined in the IOL and CL groups	110	10	In the first year, 7 reoperations were required in the CL group and 36 in the IOL group	Complications were quite low between 6-10 years, while VA was the same. Aphakia for the first 7 months was recommended
Lambert et al.[28]	2020	VA was compared between the IOL and CL groups after unilateral lensectomy	114 (57 CL + 57 IOL)	10	At 10.5 years of age, 12 children in the IOL group (22%) and 15 children in the CL group (27%) had good VA (20/40 or better). However, 25 patients in both groups had low VA (20/200 and worse)	VA results were highly variable in both groups. IOL implantation time was not a determinant of VA outcome
VanderVeen et al.[29]	2021	VA, refractive outcomes, and adverse effects were investigated in the IOL and CL group after 10 years	114 (57 CL + 57 IOL)	10	Mean VA at age 10.5 years was 0.9 logMAR (0.2-1.7) in the IOL group and 0.8 logMAR (0.1-2.9) in the aphakic group. Mean refraction at age 10.5 years was 3.20±2.70 D in the secondary IOL group and -5.50±6.60 D in the primary IOL group	Delayed IOL implantation provides more predictable refraction results

IOL: Intraocular lens, CC: Congenital cataract, VA: Visual acuity, CL: Contact lens, logMAR: Logarithm of the minimum angle of resolution, D: Diopters

Contact Lenses Options

Current CL options that can be used during infancy are rigid gas permeable contact lenses (RGPCLs), silicone elastomer (SE) lenses, and soft hydrogel and silicone hydrogel (SiH) lenses. High DK/t lenses that can be worn continuously (day and night) are needed for aphakic infants because of high hyperopia and the need for long sleep periods. While SE lenses are the first choice for this purpose, RGPCLs, SiH lenses, and less commonly hydrogel lenses are important options that can also be used in the right circumstances.[30]

Rigid Gas Permeable Contact Lenses

As RGPCLs can be produced with the desired base curve (BC) and power, they have the advantage of being available in a wide range of parameters. In addition, being able to apply a lens with the needed dioptric power and the ability of rigid lenses to mask corneal astigmatism also offer the opportunity to achieve high visual quality.[31] Furthermore, RGPCLs carry a lower risk of hypoxia and infection because they can be produced from a highly oxygen-permeable material (fluorosilicone acrylate), allow for adequate tear exchange, and have low water content.[10] However, drawbacks that limit the preference for these lenses are discomfort caused by the rigid material, difficulty during wear, having to remove them every night, and the need for more experience and expertise to determine the appropriate lens.[10,12,30]

The BC refers to the posterior surface slope of the CL, and a BC value 1.0-1.5 mm steeper than the flattest keratometry value is generally preferred.[30,31] Lens diameters vary from 7.8 to 9.5 mm and can be determined according to the diameter of the infant's cornea. Lenses can be manufactured with a lenticular design to reduce edge thickness and thus increase lens comfort.[30,31] After inserting a trial lens, its position and movement on the ocular surface and the relationship of the lens to the cornea is checked by fluorescein staining (Figure 1). Many retrospective studies have investigated vision quality and risk of adverse events with corneal and intralimbal RGPCLs (Table 2). The results of these studies indicated that despite problems such as discomfort from the rigid material, application difficulties, and the requirement of daytime use, RGPCLs are safe and effective lenses that can be used successfully in all pediatric aphakia patients, including infants.[32,33,34,35,36,37]

In addition, RGPCLs are especially used in trauma cases with irregular and high corneal astigmatism. With their good VA and ease of use, these lenses are reported to be successful options that can be preferred for pediatric traumatic aphakia.[38] Piggyback CL systems that utilize an RGPCL on top of a high oxygen permeability SiH CL can also be applied in eyes with irregular corneas and other cases where RGPCLs alone are not tolerated (Figure 2).[39] In addition, two separate studies conducted in recent years reported that mini-scleral and scleral lenses can also be used as safe and effective options in aphakic children.[40,41]

Silicone Elastomer Lenses

SE lenses are among the most preferred CL options in pediatric aphakia. One of the main reasons for this is that SE lenses have very high oxygen permeability (Dk: 340, Dk/t: 58/0.61 mm) and low water content, and thus can remain on the eye without any problems for 15 days or even up to 1 month.[30] The fact that SE lenses do not need to be removed every day increases the safety and comfort of CL wear in infancy, a period in which CL insertion and removal difficulties may be encountered. Other superior features are that they provide high VA, are easy to insert and remove due to their lenticular design and minimal flexibility, and their material is resistant to bacterial colonization (Figures 3, 4).[30,42,43,44] On the other hand, SE is an extremely hydrophobic material, which may result in the formation of excessive lipid and mucus deposits on the lens surface. Special coating methods are used to improve its surface properties. However, gradual deterioration of these surface coatings and deposit accumulation can lead to lens

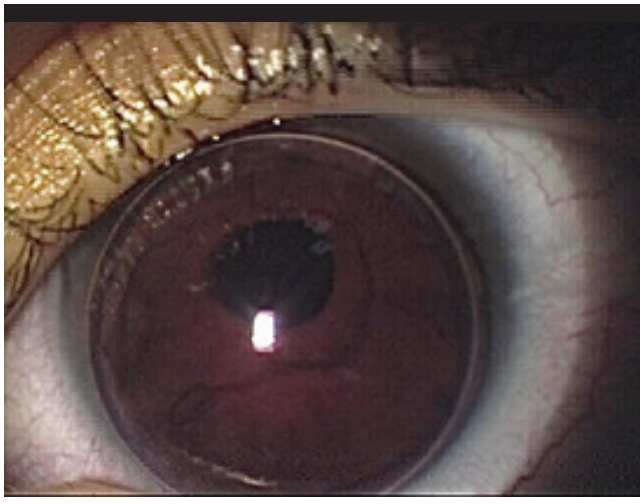

Figure 1. Optimum gas permeable rigid contact lens fitting; the lens is centered, with no slipping or tight adhesion

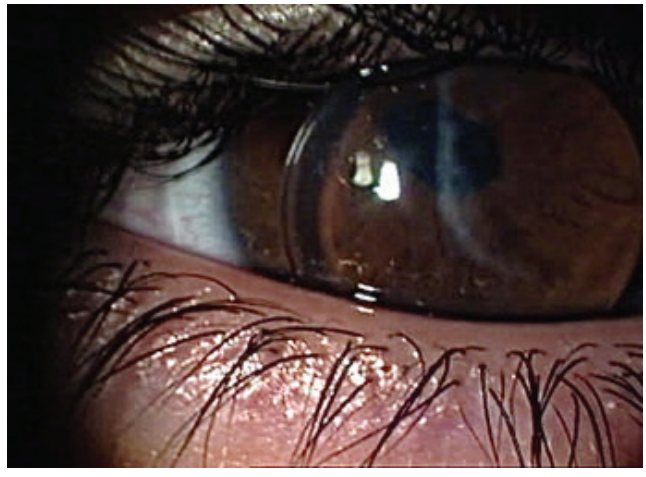

Figure 2. Piggyback contact lens fitting in a 7-year-old patient with aphakia due to trauma. A scar caused by a penetrating corneal wound passes through the center of the pupil

Table 2. Studies investigating the safety and efficacy of RGPCLs

Authors	Year	Number of patients/ eyes	Lens/power/wear schedule	Age at surgery/ follow-up period	Outcomes, VA	Adverse effects	Comments
Amos et al.[32]	1992	CC, 10 patients (15 eyes)	FluoroPerm 92 (Paragon Vision Sciences) 22-43 D Daily use	22.7 months/16 months follow-up	VA: >0.5 in 40%	1 lens dislocated to the superior fornix Lens loss rate: 2.4/year	The RGPCL is well tolerated and easily applied
Saltarelli et al.[33]	2008	CC, 10 patients (16 eyes)	Menicon Z (Menicon Co.) Intralimbal lens 23-32 D Continuous use	3 week-2 years/6 months follow-up	Well tolerated in continuous use (day and night) for 1 week.	Not reported	The RGPCL is easy to apply, effective, and safe
Loudot et al.[34]	2012	CC, 17 patients (23 eyes)	Menicon Z (Menicon Co.) Intralimbal lens	3.5 months (3 days-36 months) 1 year follow-up	VA: >0.3 in 9/12 eyes Good results in bilateral CC	3 patients discontinued CL wear Infection in 1 eye	RGPCLs are effective and reliable in the treatment of infant aphakia
Chen et al.[35]	2019	CC and PFV, 49 unilateral aphakic eyes	RGPCL Daily use	3 years (1-11 years) 4 years follow-up	Marked increase in VA if no additional pathology and good compliance to occlusion	Conjunctival hyperemia in 1 eye	The RGPCL is effective and safe in unilateral aphakia
Zhang et al.[36]	2019	CC, 36 unilateral aphakic eyes	OCUVIQ (Oculus) 23.9±4.2 D Daily use	7 months (5-13 months) 5 years follow-up	VA: 1.2±0.7 logMAR 69% continued CL use	Moderate conjunctivitis in 1 patient Difficulty applying and irritation	They are effective and safe lenses that can be well tolerated
Kooshki et al.[37]	2022	CC, 76 unilateral aphakic eyes	RGPCL	3 years	VA: 0.98±0.62 logMAR 8 children were diagnosed with suspected glaucoma.	27.6% of parents did not comply with occlusion therapy	It is a safe and effective method that can be well tolerated by children and parents

RGPCL: Rigid gas permeable contact lens, CC: Congenital cataract, PFV: Persistent fetal vasculature syndrome, D: Diopters, VA: Visual acuity, logMAR: Logarithm of the minimum angle of resolution, CL: Contact lens

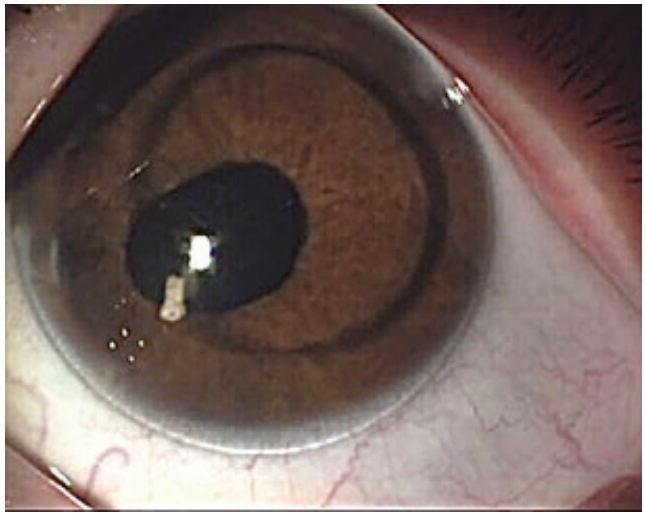

Figure 3. Optimum Silsoft contact lens fitting in a 4-year-old child with unilateral aphakia

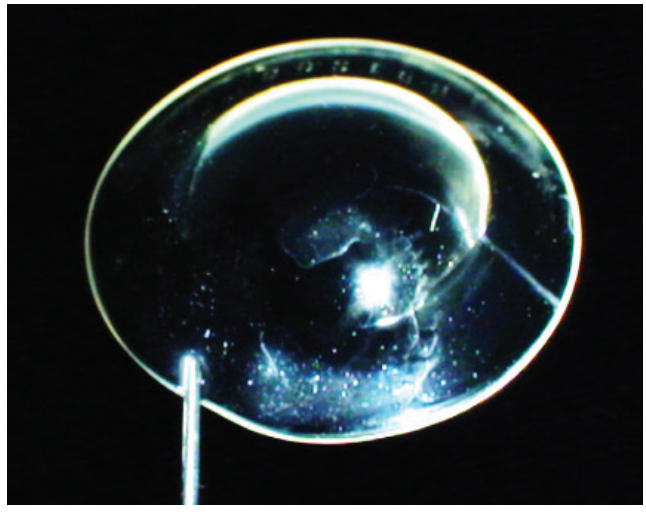

Figure 4. The lenticular design of the Silsoft contact lens with a thick 7-mm thick optic zone in the center and a thin periphery provides easy insertion and comfortable wear

wetting problems and visual disturbances (Figures 5, 6).[45,46] In addition, silicone is a waterproof material and the lens frequently adheres to the eye.[47] In addition to their surface issues, SE lenses usually need to be replaced every 3-6 months due to rapid refractive changes associated with infant development. As a result, the need to frequently replace these lenses increases the financial burden on families, and production and supply problems in recent years necessitated a search for different lens options.[42]

Currently produced and available SE lenses are the Silsoft® and Silsoft® Super Plus (Bausch & Lomb Incorporated, Bridgewater, NJ, USA). Silsoft® Super Plus lenses are often used in early infancy in parallel with the development of the child. These lenses come with BC options of 7.5, 7.7, and 7.9 mm, their diameter is 11.3 mm, and their power values range from +23.00 to +32.00 D in 3.00-D steps (+23.00, +26.00, +29.00, and +32.00). In addition, Silsoft® aphakic lenses for use at older ages are available with 5 BC options (7.5, 7.7, 7.9, 8.1, and 8.3 mm), 2 diameters (11.3 and 12.5 mm), and power options ranging from +11.50 to +20.00 D in 0.50-D steps.[30,43]

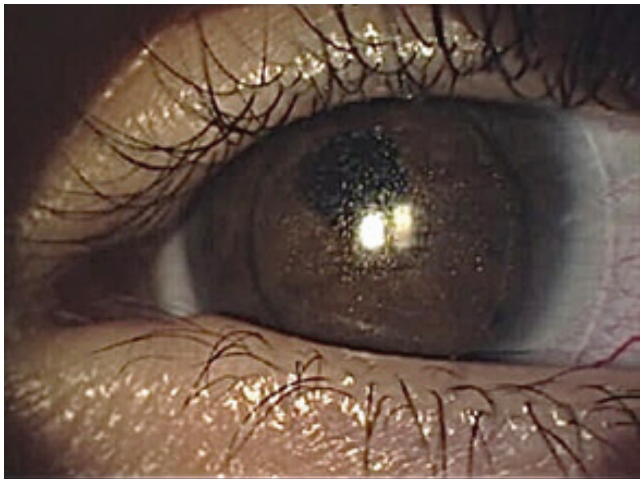

Figure 5. Surface irregularity and deposits on a Silsoft contact lens

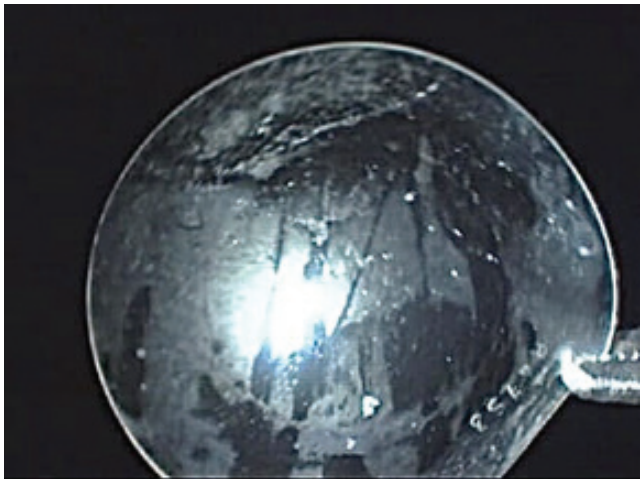

Figure 6. Emergence of the hydrophobic structure and blurring of a Silsoft contact lens due to deterioration of surface coating

The efficacy and safety of SE lenses have been investigated in many studies, both as a first-line choice and in comparison to RGPCLs (Table 3).[48,49,50,51,52] The common conclusion reached in these studies was that SE lenses can be used safely and effectively in the pediatric age group due to their ease of use, the advantages of extended wear, and the low rate of adverse events.[48,49,50] Additionally, the multicenter, prospective, randomized Infant Aphakia Treatment Study (IATS) examined the 1-year and 5-year results of unilateral aphakic children who underwent optical rehabilitation with SE lenses and RGPCLs. At the end of the 1-year period that was the first part of the study, it was reported that regardless of the lens type, successful VA results (+0.80 logarithm of the minimum angle of resolution [logMAR]) could be achieved with few adverse effects.[51] According to 5-year follow-up data from the same study, VA better than 20/40 could be reached in 33% of those using RGPCLs and 20% of those using SE lenses, there was no significant difference in visual prognosis between the two lens types, and few adverse events were observed.[52]

Soft Lenses: Hydrogel Lenses and SiH Lenses

Hydrogel lenses can be used in infancy and later childhood for pediatric aphakia. The low oxygen permeability of the hydrogel material may cause an increased risk of various complications such as corneal edema, neovascularization, endothelial polymegathism, and infective keratitis. Although lenses with high water retention can be used in aphakia to reduce the hypoxic complications of these lenses, oxygen permeability is reduced in high plus power lenses because of the thick central zone (i.e., the Dk/t ratio is still low). For this reason, daily insertion and removal is considered safe and effective.[53,54]

In contrast, SiH lenses have high oxygen permeability and provide an important advantage in preventing corneal complications associated with hydrogel lenses. However, since the increased lens thickness required for high power also reduces Dk/t (i.e., oxygen transmission), SiH aphakic lenses are mostly used for daily use in infancy and early childhood. In addition, they offer low water content, ease of use, and the opportunity for frequent replacement.[55,56] Custom-made SiH lenses are also available now.[57] In our country, CLs produced from SiH material (Definitive 74: Filcon V3, water content: 74%, Dk [Fatt; mmHg]: 60) and replaced every 3-6 months can be used (Figure 7). As CL dioptric power decreases with age, children can be switched to SiH and hydrogel lenses, which are available within the production parameter ranges and can be applied in a daily use/monthly replacement regimen (Figure 8). There are also domestically produced aphakic CL options made of materials suitable for daily use (NL64: MMA-N-vinyl-pyrrolidone copolymer, water content: 67%, Dk/t: 36 @ -3.00 D).

The efficacy and safety of soft CLs have been investigated in various studies over the years. In their prospective 3-year follow-up study of 141 eyes of 83 infants, Amaya et al.[58] shared the results of daily use of hydrogel CLs with water content

Table 3. Studies of SE (first-line choice) and SE/RGPCL (comparative)

Authors	Country/year	Number of patients/ eyes	Age at surgery/ follow-up period	Lens specifications/ wear schedule	Outcomes VA	Complications	Conclusion
Aasuri et al.[48]	India/1999	74 patients (106 eyes) with CC	9 months (1 month-12 years)/5 years follow-up	Silsoft® Super Plus (Bausch+Lomb) Continuous use (replacement after ≥1 week)	Increased in 45%	23 mild adverse events 2 microbial keratitis 3 scar	SE lenses are reliable and easy to use
de Brabander et al.[49]	Netherlands/2002	17 CC patients (26 eyes: 8 unilateral, 18 bilateral)	Infancy / 6 years follow-up	Silsoft® Super Plus (Bausch+Lomb) Continuous use	0.1-0.3 in 15 eyes 0.3-0.5 in 10 eyes >0.5 in 1 eye	No major complications Deposit formation was frequent	SE lenses are easy to use, logical, and safe
Ozbek et al.[50]	Turkey/2002	51 CC patients (83 eyes)	19±18 months	Silsoft® Super Plus (Bausch+Lomb) Initial lens power +29.0 D,	VA increased in 58 eyes (70%), was unchanged in 25 eyes	2 redness, itching 1 recurrent corneal infiltration	Safe for prolonged wear, easy to use, low rate of lens discontinuation
Russell et al.[51]	Multicenter/2012	57 CC patients, all unilateral	1-6 months 1 year follow-up	42 (74%) SE (Silsoft® Super Plus; Bausch+Lomb) 12 (21%) RGPCL (Boston XO2; X-Cel Specialty Contacts) 3 (5%) SE + RGPCL Wear schedule: SE: Continuous (7-21 nights) RGPCL: Daily	VA increased in 95% VA was +0.80 logMAR for both groups Measured with Teller Acuity Cards	SE: 1 corneal abrasion, 1 bacterial keratitis, 1 corneal opacity RGPCL: None	Successful outcomes were achieved in unilateral aphakia with few adverse effects, regardless of CL type
Russell et al.[52]	Multicenter/2017	52 eyes continued CL use	1-5 years follow-up	24 (46%) SE (Silsoft® Super Plus; Bausch+Lomb) 11 (21%) RGPCL (Boston XO2; X-Cel Specialty Contacts) 17 (33%) SE + RGPCL Wear schedule: SE: Continuous, RGPCL: Daily	VA: Better than 20/40 in 33% of RGPCL users and 20% of SE users	SE: 6 keratitis, 3 recurrent corneal opacities, 2 corneal abrasions RGPCL: 1 in situ broken lens	CLs yielded successful results with relatively few adverse effects

SE: Silicone elastomer, RGPCL: Rigid gas permeable contact lens, CC: Congenital cataract, D: Diopters, VA: Visual acuity, logMAR: Logarithm of the minimum angle of resolution, CL: Contact lens

that was initially high and decreased with age. The authors reported that 85% of the patients continued CL use, but 46 eyes had significant complications such as bacterial conjunctivitis, hypoxic corneal ulcer, corneal edema, and pannus formation.

Chen et al.[59] retrospectively examined factors affecting VA in 5 infants with unilateral idiopathic CC and 10 infants with cataract secondary to PFV who received various daily use hydrogel CLs after cataract surgery. Successful VA outcomes (20/50 or better) were obtained in 50% of unilateral aphakic children over the age of 5 years. Surgical or ocular complications were found to negatively affect VA in the PFV group. The authors concluded that compliance with CL and patching was directly related to VA. In addition, they reported that the most common CL-related complications were corneal pannus (26.66%) and giant papillary conjunctivitis (20%), and 60% of the patients were switched to an RGPCL for this reason.

In their study examining 205 patients, 173 (84.4%) with RGPCLs and 32 (15.6%) with soft CLs, Subramanian[60] found that only half of the children successfully continued CL use, the highest VA achieved was 0.2 logMAR in a 4-year-old successful CL user, and visual success depended on correct CL selection and close follow-up.

The results of these studies conducted over approximately 30 years indicate that complications associated with daily use soft CLs have decreased over time, VA can reach fairly high levels, and correct CL selection and compliance with patching are directly related to visual success.[58,59,60]

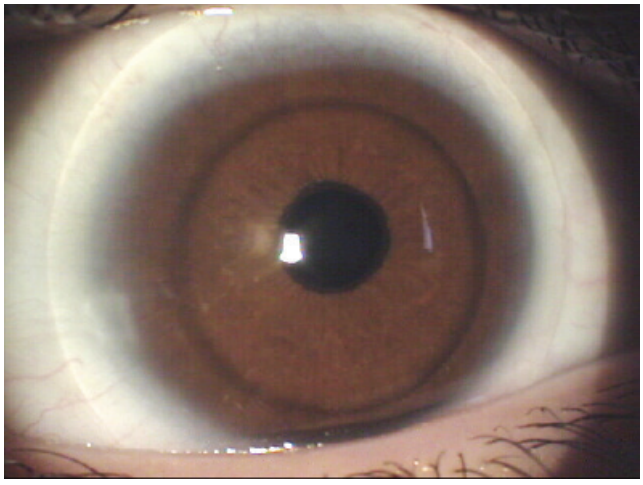

Figure 7. Fitting of a daily silicone hydrogen contact lens in a 4-year-old child with unilateral aphakia

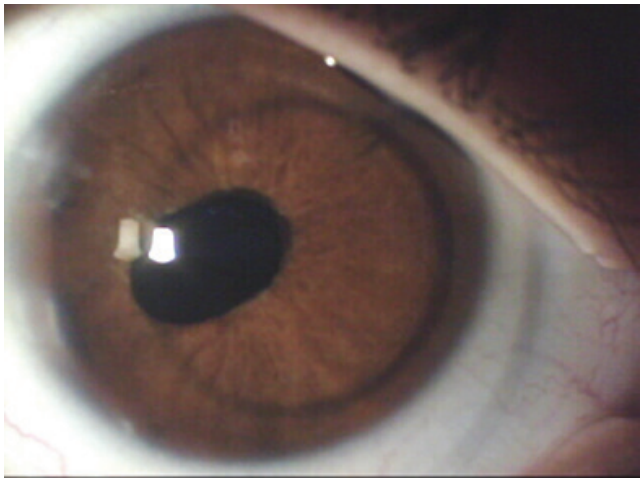

Figure 8. A 10-year-old child with unilateral aphakia fit with an 18-D, daily use hydrogel contact lens (Omafilcon A, water content: 62%, Dk/t: 42 @ -3.00 D) replaced every 15 days

Contact Lenses Fitting and Patient Compliance

Dioptric power, BC, and diameter are important parameters in CL fitting, and among their determining factors, axial length, keratometric values, corneal diameter, and aphakic refractive error vary with age, especially in infancy (Table 4).[61,62] However, eye development differs in pediatric aphakia. Axial elongation may be affected by surgery, visual deprivation, optical defocus, or various potential pathologies associated with cataract (e.g., glaucoma, PFV).[63] Therefore, CL parameters should be determined by evaluating each child within the framework of these specific changes, as well as the natural developmental process of the eye.

Base curve and diameter selection: It may not always be possible to determine corneal keratometric values during infancy. Therefore, the BC value and diameter of the initial lens are often determined according to the infant's age. When fitting Silsoft CLs, a 7.5 mm BC and 11.3 mm diameter are preferred as a rule because the infant cornea has a steep anterior surface slope and small diameter. As the corneal curvature will flatten by the age of 2 years, most children are switched to a 7.7 mm BC. However, in some children the cornea can maintain its steep slope and an SE lens with 7.5 BC can be used into later childhood. A steep fitting incompatible with the corneal anterior surface slope causes the lens to become immobile, while a flat fitting can lead to keratitis due to the central mechanical effect (Figure 9).[30,31,57]

The basic principles of soft CL fitting are similar to those in adults. The BC should generally be 0.5 mm flatter than the corneal slope (which is ~6.9-7.1 mm at birth), which corresponds to about 7.4 mm. Moreover, the diameter of soft CLs should be 2.5-3.0 mm greater than the entire corneal diameter (i.e., 12.5 or 13.00 mm) to ensure lens stability and prevent dislocation. Again, these values are modified as the patient grows.[57]

Determination of contact lenses power: Realistically, determining the dioptric power is more difficult than selecting the BC value. For this reason, the IATS working group protocol recommended that in cases where refractive error cannot be measured precisely, the initial lens power should usually be +32 D for Silsoft lenses and then modified as necessary as early as possible.[63] In their study with 50 patients who underwent

Table 4. Axial length, keratometry, and aphakic refractive error values according to age group*

Age range (years)	Axial length (mm)	Keratometry (D)	Aphakic refractive error (D)
0-1	19.2	45.2	18.77
1-2	20.2	44.9	16.87
2-3	21.4	44.1	15.00
3-4	21.8	43.7	14.51
4-5	22.3	43.2	13.92
5-6	22.7	43.7	12.84
6-7	22.9	43.4	12.69
7-9	22.6	44.2	12.67
10-15	23.8	43.5	11.02

*Axial length and keratometry cited from a study by Gordon and Donzis[61]; aphakic refractive errors from McClatchey and Hoffmeister[62]
D: Diopters

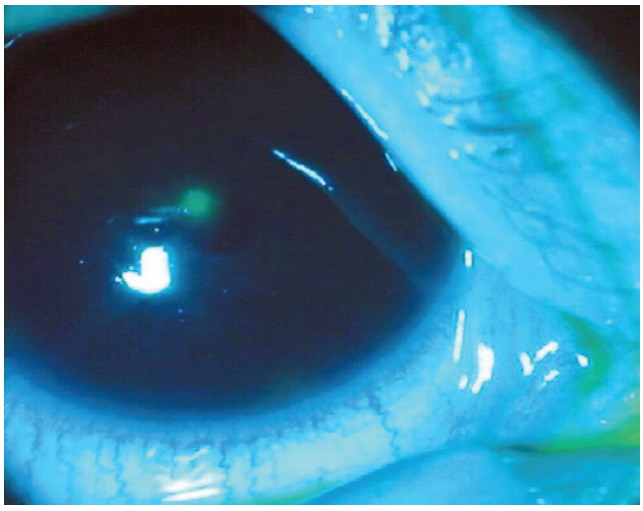

Figure 9. Central keratitis in a 5-year-old unilateral aphakic child caused by the mechanical effect of a flat-fitting silicone elastomer contact lens

cataract surgery at 2.4±1.7 months of age, Trivedi and Wilson[64] determined the mean refractive error was 29.6±4.4 D in the corneal plane and showed that lens replacement may be required in 22 of the 50 patients (44%) if a +32 D CL were used. Other researchers have reported that postoperative refraction examination may be difficult in infants and that estimating the CL power before surgery with the help of preoperative biometrics may reduce the need for lens change. On the other hand, the infant's refractive error can change rapidly in the first year after birth, after which this rate of change gradually decreases. Therefore, it is important to verify CL dioptric power and compliance monthly for the first 18 months and then every 3 months for the next 3 years.[53,54,55,56,57]

Contact lenses fitting and evaluation: While a CL can be inserted immediately after surgery, it is usually preferrable to have it applied at postoperative 1 week by an ophthalmologist in office conditions, after the infant is laid supine in the examination room, with head and arm movements minimized by the parents. The family is taught about CL insertion and removal in every detail and in practice. Fifteen minutes after CL insertion, lens movement and centration are evaluated, as well as fluorescein staining patterns for RGPCLs and SE lenses. SE lenses can be relatively easily applied to the small infant eye due to their thickness and design.[65] SiH lenses can also be applied more easily than hydrogel lenses due to their high modulus of rigidity.[57] The infant is examined at 1 day, 1 week, 1 month, and 3 months after fitting, after which follow-up can be recommended at least 4 times a year depending on the condition of the case. Corneal complications and pathologies such as glaucoma and retinal problems are evaluated. Surface problems specific to SE lenses can frequently occur. Due to these surface problems and dioptric changes parallel to eye growth, most patients may require lens replacement in 3-6 months.[30,65]

Contact lenses wear time: SE lenses are fitted immediately or within the first week after surgery and can remain in the eye for up to 30 days unless there is a problem. However, most practitioners prefer that SE lenses are removed every 1 or 2 weeks and inserted the next morning after a night of rest.[30] Although parents initially have difficulty with the process of inserting and removing the lenses, they gradually gain experience and can often do it more easily while the infant is feeding or falling asleep. These lenses can be cleaned and disinfected with multi-purpose soft CL solutions. The recommended time for adequate disinfection is reported as 8 hours. In the early years, eye rubbing commonly results in ejection of a CL from the infant's eye, and it may be found in their bed or among their toys.[30,52]

Calculation of spectacle power over the contact lenses: Although measurements can be made with a pediatric autorefractometer, the retinoscope is primarily used in all circumstances. If over 1.5-2 years of age, spectacle correction over the CL for near vision (+2.0/+2.50 D) can be provided as monofocal, bifocal, or progressive according to the patient's age.[50,53]

Contact lenses compliance: As both the child's reaction to CL wear and the parent's adherence play a role in CL compliance, they can be evaluated together. All infants initially react to CL insertion, but with time their reactions to this process decrease, or contrariwise, they may reject lens use as they grow. The CL adherence of the family should be assessed according to their success in inserting and removing the lens and the continuity of wear.[66]

Amblyopia Risk and Occlusion Therapy

The first weeks and months of life are a critical time for the development of amblyopia. An inadequate retinal image during this sensitive period hinders the formation of good visual perception in the occipital cortex and negatively impacts vision development.[67] However, if amblyogenic risk factors are reduced or eliminated in the early period, vision loss can be avoided thanks to the plasticity of the brain. Therefore, unilateral or bilateral cataracts detected in the neonatal period should be operated as soon as possible, refractive correction should be provided with the most appropriate CL and/or glasses immediately afterwards, and patching treatment for amblyopia should be initiated, especially in unilateral aphakia. In addition, attention should be paid to the risk of occlusion amblyopia that may occur in the other eye with excessive patching.[68] In bilateral cataract, the risk of amblyopia may be less and occlusion therapy may not be required if there is no strabismus. In acquired cataracts, the risk decreases but can continue until 5 years of age or later.[69,70,71,72,73]

The duration of patching treatment is determined according to the patient's age, unilateral or bilateral involvement, and their fixation and deviation status. This procedure is done using adhesive patches or patching tapes suitable for infants and children and requires complete occlusion of the well-sighted eye. The child is asked to play with near objects during the

patching period, and as they grow they are asked to identify and track pictures and shapes in a book or digital environment while wearing near-glasses.[74,75]

There are different patching regimens, such as patching methods tailored according to the VA of the fixating or treated eye, but none has been shown to be superior over the others.[76,77] Lambert et al.[78] from the IATS group started patching treatment 2 weeks after cataract surgery and defined the patching duration as 1 hour per day for each month of age for the first 8 months, then half of their waking hours each day or their entire waking time every other day.

Adherence to patching is one of the factors that has the greatest impact on vision development in unilateral aphakia.[79,80] To enable an objective evaluation, the information conveyed by parents in phone calls or written logs can be used as a primary source.[81,82] However, these practices require years of attention and dedication and are a significant source of tension and anxiety for children and families.[83] Several studies have shown that pediatric cataract significantly impairs the social and functional quality of life of the patient and their family.[84,85,86] As the stress experienced by families can have many important effects on children, from behavioral disorders to maladaptive parental approaches, it is important to evaluate this during the treatment of pediatric aphakia. Sources of stress and the factors influencing treatment adherence vary from the choice of treatment method to cost-related issues, and may change in severity as the child grows.[87,88]

Contact Lenses Fitting and Follow-up in the Presence of Additional Pathologies

Persistent fetal vascular syndrome: The anatomic involvement in PFV is diverse and can be classified based on location as anterior, posterior, or combined.[89,90] Although it has been reported that visual gain is likely to be low in these cases, many studies have suggested that successful visual outcomes can be achieved in anterior PFV through early diagnosis, carefully planned surgical treatment, appropriate optical correction, and effective amblyopia treatment.[91,92,93,94,95] Because PFV is often associated with microphthalmia, it may be difficult to obtain lenses with appropriate corneal BC, diameter, and dioptric power values. Such cases can be approached by first using glasses for optical correction and later switching to a CL when corneal parameters become suitable, or fitting can be attempted with different CL options.[30,35]

Glaucoma: Glaucoma is a common pathology in pediatric aphakia, reported to occur at rates of approximately 12% in the 1-year results of the IATS study and 30% in the 5-year study, independent of the treatment modalities applied. This emphasizes the importance of close follow-up and treatment in aphakic children regardless of the optical correction used.[96,97,98] In infants who develop glaucoma, SE lenses may be advantageous because their use is suitable for medical treatment.[54] In cases of buphthalmos, it may be more appropriate to continue with glasses, considering that the corneal diameter and keratometric values will change and the refractive error will decrease to lower values.[99,100]

Study Limitations

Apart from the IATS study, most previous studies have been retrospective and consisted of case series. Small patient samples and inadequate follow-up periods are limitations of these studies, as well as variability in many parameters that can affect vision, such as cataract type, surgical timing, timing of postoperative CL fitting, and family adherence to CL and patching treatment. Therefore, there is a need for long-term prospective studies that minimize these limitations to the evaluation of safety and efficacy and directly compare visual outcomes and quality of life with various CLs and amblyopia treatments in different patient groups.

Conclusion

Aphakia is an important problem that can affect a child's future, especially given the associated risk of deep amblyopia in the neonatal and infancy periods. Therefore, it is necessary to initiate treatment for vision development as soon as possible after cataract surgery. With their low risk and high efficacy, CLs have an important place in the treatment of aphakia in infants and young children up to 2 years of age. Although a wide range of lenses can be used in pediatric aphakia, SE lenses with high Dk/t values that enable continuous day and night wear are often preferred.[30] However, RGPCLs, SiH lenses, and more rarely hydrogel lenses are other important options that can also be used under the right conditions.[34,36,56] Despite this development and diversification in CL materials and technology, family adherence to CL use and occlusion therapy is the main factor affecting success.[79,80] With early diagnosis, early surgery, CL fitting as soon as possible after surgery, and full compliance with patching treatment, it is now possible to reach very high levels of vision.[7,14] However, there is still a lack of knowledge and experience related to the efficacy and safety of treatments being provided, and there is a need for more comprehensive scientific studies with long-term follow-up in which data can be standardized.

Ethics

Authorship Contributions

Concept: T.Ş., T.G.A., Design: T.Ş., T.G.A., Data Collection or Processing: T.Ş., T.G.A., Analysis or Interpretation: T.Ş., T.G.A., Literature Search: T.Ş., T.G.A., Writing: T.Ş., T.G.A.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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