Chapter 22
Intraocular Lens Placement in the Setting of Glaucoma

Emily M. Zepeda and Brenda L. Bohnsack

Glaucoma in the Setting of Aphakia

The most common clinical scenarios in which glaucoma complicates aphakia are glaucoma following cataract surgery and uveitic glaucoma. Intraocular pressure (IOP) management must take precedence as substantial vision loss due to glaucoma negates the importance of intraocular lens (IOL) placement for visual rehabilitation. In both glaucoma following cataract surgery and uveitic glaucoma, topical antihypertensive medications are the first-line treatment for increased intraocular pressures [1, 2]. In eyes refractory to medications, the choice of traditional surgical options including goniotomy, trabeculotomy, trabeculectomy, glaucoma drainage devices, and cycloablation (transscleral and endoscopic) is dependent on factors such as angle configuration, corneal clarity, eye size, and previous eye surgeries [3–11]. Glaucoma surgery that is required to obtain IOP control should be done prior to secondary IOL placement.

Evidence of good IOP control includes serial pressure measurements, reversal of optic nerve cupping, resolution of corneal edema, and stabilization of corneal diameter and axial length. While axial lengths measured via A-scan ultrasound or optical biometry systems (i.e., Lenstar®, IOL-Master®) are most accurate, they may not be plausible in-clinic options for young children. In this case, stabilization of the refraction may be an acceptable substitute. For the purpose of IOL selection, it is important to note that in glaucomatous eyes with buphthalmos, rapid intraocular pressure control obtained through glaucoma surgery often causes a sudden decrease

E. M. Zepeda
Department of Ophthalmology, Dean McGee Eye Institute,
University of Oklahoma, Oklahoma City, OK, USA

B. L. Bohnsack (✉)
Department of Ophthalmology and Visual Sciences,
Kellogg Eye Center, University of Michigan, Ann Arbor, MI, USA
e-mail: brendabo@med.umich.edu

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in axial length followed by a slower re-expansion of the globe. The final length may fall between the immediate postoperative and the maximum buphthalmic eye lengths [12, 13]. Thus, selecting a lens based on a buphthalmic measurement can result in a hyperopic shift, while not waiting until axial length stabilization following glaucoma surgery may cause a more myopic end refraction [14, 15].

Intraocular Lens Placement in Glaucoma Following Cataract Surgery

Following congenital cataract extraction, it is well-known that the newly rendered aphakic eye is at high risk for developing glaucoma, with an incidence ranging from 15% to 50% [16, 17]. In these patients, elevated IOP is often observed within the first few years after surgery but can occur years later, highlighting the importance of diligent, lifelong surveillance.

The majority of cases of glaucoma following cataract surgery have an open-angle configuration and arise directly because of the aphakic status [16–19]. In these cases, the angle typically has a normal appearance both prior to and following cataract surgery making it unclear as to the pathogenesis of this form of glaucoma [20, 21]. Since the most notable risk factor is age at the time of cataract surgery, with infants under the age of 2 months having the highest rate of glaucoma, the mechanistic theories revolve around the lens, mechanically (tension from the lens on the ciliary body) and/or molecularly (secreted factors), being required for angle and aqueous outflow channel development [16, 19, 22]. Additional theories suggest that post-surgical inflammation or vitreous factors released after breaking the anterior hyaloid damage the aqueous channels [23]. In these cases, antihypertensive medication is the first-line treatment; however, up to 50% of eyes require glaucoma surgery for IOP control [24, 25]. Angle surgery (goniotomy or trabeculotomy) is typically the primary glaucoma surgery and has a 50–70% success rate [26–30]. If angle surgery fails to control IOP, many patients will have placement of a glaucoma drainage device [31, 32]. In eyes that are aphakic, placement of the tube in the pars plana with a concurrent vitrectomy should be considered. This is especially true if a secondary IOL will be implanted in the future [33–35]. Additional patients may undergo trabeculectomy, although filtering surgeries with adjunctive anti-fibrotics have become less popular in the pediatric population due to the lifelong risk of endophthalmitis [36, 37]. Another option is cyclophotocoagulation, which can be successfully used to control IOP either alone or in conjunction with glaucoma drainage devices [38].

In some cases of glaucoma following cataract surgery, there is a narrow-angle or a closed-angle configuration. In these eyes, there are often preexisting pathologic states such as microphthalmia and/or microcornea [16, 18]. Elevated IOP may develop early during childhood due to the congenital anatomically shallow anterior chambers. In addition, glaucoma may be diagnosed in late childhood to adulthood

due to further crowding of the anterior chamber from the Soemmering ring, which gradually increases in diameter due to proliferation of the lens epithelial cells and cortical fibers within the posterior and anterior capsules [39–41]. In these situations, angle surgery often fails, and glaucoma drainage device implantation is typically used to obtain IOP control [33]. However, given the shallow anterior chamber, the safest place for the tube is posteriorly placed within the pars plana.

Case 1

The patient is a 9-year-old girl with a history of congenital cataracts with microphthalmia of both eyes. She underwent cataract extraction of the right eye at 6 weeks of age and the left eye at 7 weeks of age. Her vision was corrected with contact lenses, which she tolerated well. She was diagnosed with glaucoma following cataract surgery in both eyes at 7 years of age and underwent combined 180-degree trabeculotomy with trabeculectomy at 8 years of age. However, her intraocular pressure in her right eye remained uncontrolled, and she was referred for further treatment.

At the time of presentation, the patient's best-corrected visual acuity with +20.0 SilSoft® contact lenses was 20/40 in the right eye and 20/25 in the left eye. The intraocular pressures by Goldmann tomometry tonometry were 30 mmHg in the right eye and 17 mmHg in the left eye on timolol, dorzolamide, brimonidine, and latanoprost in both eyes. Slit lamp examination showed that both corneas were thin and clear (Fig. 22.1a). The right cornea was 9 mm in diameter, and the left cornea was 10 mm in diameter. The anterior chambers were shallow with approximately 2.5 mm depth centrally and 0.5 mm depth peripherally. Both eyes were aphakic and had Soemmering rings. Fundoscopic examination showed a dysplastic optic nerve with a cup to disc ratio of 0.8 in the right eye. The left eye had a cup to disc ratio of 0.1. The macula, vessels, and retinal periphery of both eyes were normal.

For glaucoma control, the patient underwent pars plana placement of a Baerveldt® 350 glaucoma drainage device with concurrent vitrectomy in the right eye at 9 years of age. This was followed by pars plana placement of a Baerveldt® 350 glaucoma drainage device with concurrent pars plana vitrectomy in the left eye at 10 years of age.

At 12 years of age, the patient desired placement of IOLs. At that time, her best-corrected visual acuity was 20/20 in each eye. Slit lamp examination showed blebs over the superotemporal Baerveldt plates in both eyes. Intraocular pressures by Goldmann applanation tonometry were 15 mmHg in both eyes on no glaucoma medications. The right optic nerve showed reversal of cupping with a color cup to disc ratio of 0.3 (Fig. 22.1b). Axial lengths measured 20.4 mm in the right eye and 19.73 mm in the left eye, and keratometry was 42.39 × 44.64 @ 98 in the right eye and 44.57 × 45.82 @ 94 in the left eye. The patient underwent serial placement of a three-piece acrylic lens in the sulcus in both eyes.

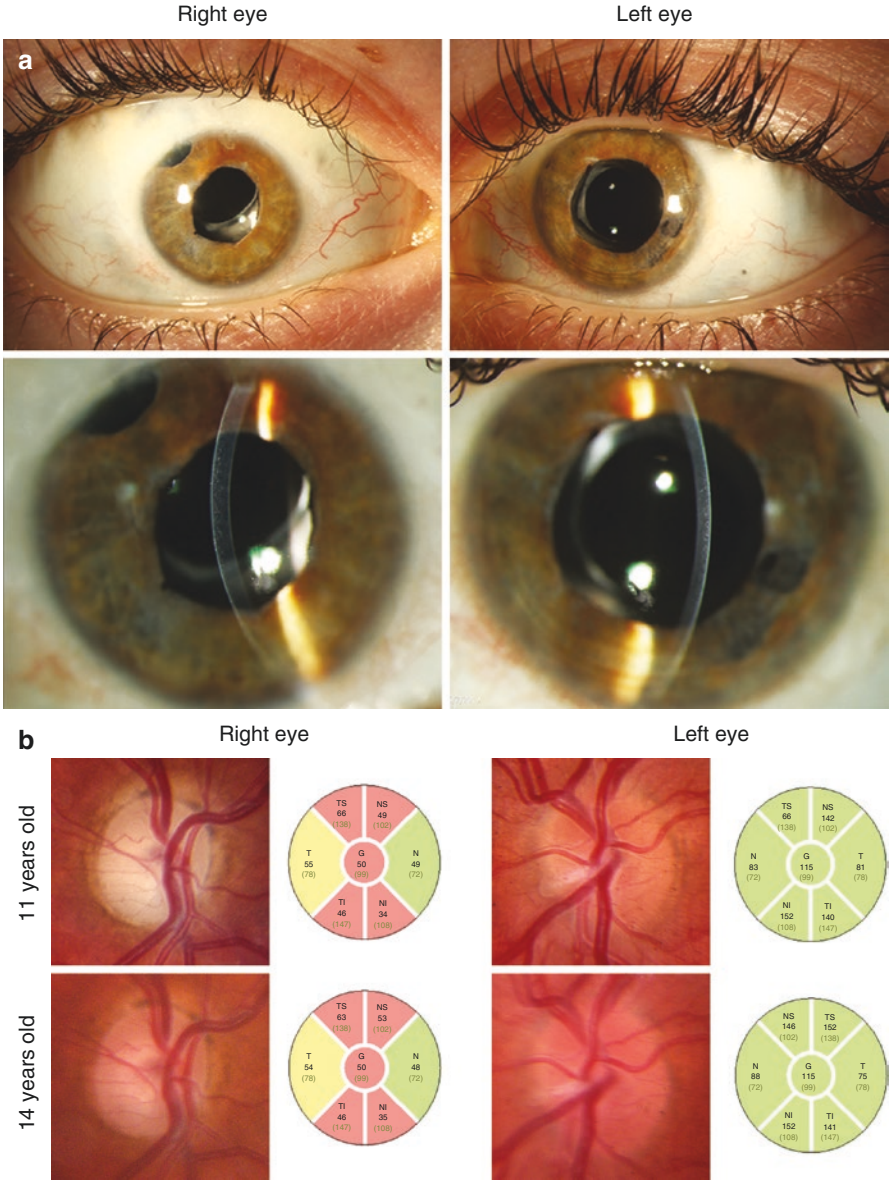


Fig. 22.1 Case 1. (**a**) External and slit lamp photographs of the right and left eyes at time of final follow-up in Case 1 demonstrated bilateral microcornea with shallow anterior chambers. Intraocular lenses were in good position, anterior to the Soemmering rings in both eyes. The superotemporal scleral patch graft was seen in the right eye, but was covered by the upper lid in the left eye. The tubes in both eyes were in the pars plana and thus not evident in the photographs. (**b**) Optic nerve photographs and optical coherence testing prior to intraocular lens placement (11 years of age) and at final follow-up (14 years of age) showed no glaucomatous progression. (**c**) Humphrey visual field testing demonstrated a superior arcuate and an early inferior arcuate defect in the right eye that correlated with the retinal nerve fiber layer thickness. Visual field in the left eye was full

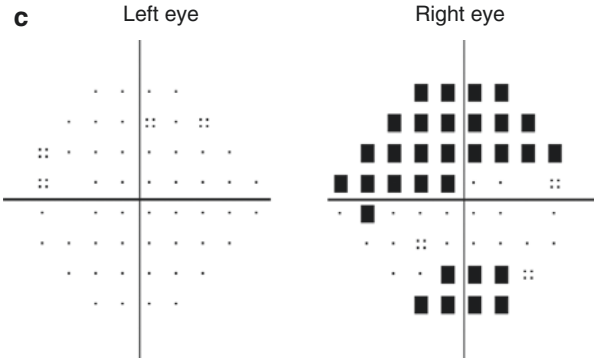


Fig. 22.1 (continued)

At final follow-up at 14 years of age, the patient's uncorrected visual acuity was 20/20 in each eye. Her intraocular pressures by Goldmann applanation tonometry were 16 mmHg in the right eye and 15 mmHg in the left eye on no glaucoma medications. She had superotemporal blebs over the Baerveldt plates, thin and clear corneas, shallow anterior chambers, and sulcus IOLs in both eyes. The optic nerves were stable in appearance (Fig. 22.1b) as was retinal nerve fiber layer thickness and visual field testing (Fig. 22.1c) compared to before IOL placement.

Comment Placement of a secondary IOL in an eye with glaucoma following cataract surgery requires IOP control and recognition of the angle and anterior chamber anatomy. Special consideration should be given to the anatomical features of the aphakic eye with glaucoma when deciding whether to place the lens in the sulcus or the capsular bag [42, 43].

Secondary IOLs are typically placed within the sulcus, using the Soemmering ring as a scaffold [44]. However, in the setting of glaucoma, placement of the IOL within the sulcus may further impede outflow through the trabecular meshwork especially in eyes with shallow anterior chambers due to microphthalmia or microcornea. Furthermore, in eyes that have previously undergone angle surgery, gonioscopy should be done prior to IOL placement to evaluate patency of the cleft and the amount of space within the peripheral anterior chamber. Another consideration for the surgeon is that commercially available one-piece acrylic lenses (Alcon® SA60AT) come in powers up to 40 diopters; the three-piece acrylic lenses (Alcon® MA60AC) only have a maximum power of 30 diopters. Especially in small, microphthalmic eyes, placement of a high-power one-piece lens within the capsule allows for greater accuracy in achieving the target refraction.

In order to minimize anterior chamber crowding, maintain patency of the angle, and place the IOL within the capsule, the Soemmering ring needs to be opened and debulked [43]. In this procedure, a 4–5-clock-hour peritomy is created. A 3 mm scleral tunnel is centered within the incision, and a stab incision at the limbus is made on each side of the tunnel. An anterior chamber maintainer is placed through one of the stab incisions. A MVR blade, placed through the other stab incision, is used to

separate the anterior and posterior capsules where they are fused centrally. Care should be taken to open the ring 360 degrees for maximal removal of lens material. The vitrector is then used to remove the proliferated cortical fibers and lens epithelial cells within the capsule. Dense Soemmering rings with hardened, calcified cortical fibers may not be easily removed with the vitrector. Viscoelastic can be injected into the anterior chamber, and the calcified fibers can be prolapsed out of the capsule in the anterior chamber. The scleral tunnel is then opened with a keratome, and the calcified fibers can be removed "extracapsular" style through the scleral tunnel. Following removal of the remnant lens fibers, the anterior and posterior capsules are inspected. If there is adequate support, then the IOL can be carefully placed within the capsule. If the posterior capsule does not have enough support, the entire IOL can be placed in the sulcus, or only the haptics can be placed in the sulcus with optic capture. A third option for older teenagers (>16 years of age) and adults is complete removal of the Soemmering ring and capsule and placement of a scleral-fixated IOL.

In microphthalmic eyes with glaucoma, if the aqueous outflow is not dependent on the angle, a secondary lens can be placed in the sulcus without debulking the Soemmering ring as described in the case above. In this example, the patient's intraocular pressures were controlled by glaucoma drainage devices allowing the lenses to be placed in the sulcus and the Soemmering ring left intact. It is important to note that in both eyes the tube portion of the glaucoma drainage device was preemptively placed in the pars plana in a combined procedure with a vitrectomy [33]. Posterior placement of the tube serves two purposes: (1) long-term prevention of corneal decompensation in a shallow anterior chamber and (2) better positioning of the tube for later placement of a secondary IOL [33, 34, 45]. In aphakic eyes with glaucoma drainage devices previously placed within the anterior chamber, consideration should be given to moving the tube to the pars plana either in conjunction with or prior to placement of a secondary IOL. The disadvantage to posterior placement of glaucoma drainage devices is the need for concurrent vitrectomy. Coordination of surgery between retina and glaucoma specialists can be difficult but decreases the need for multiple surgeries and improves communication to ensure adequate vitreous removal in the area of the tube. The increased risk of retinal detachment due to vitrectomy is low and outweighs the risk of corneal decompensation, especially in eyes with crowded anterior chambers [33–35, 45]. With pre-planning and appropriate tube placement, Case 1 demonstrates how sulcus placement of a secondary IOL achieves excellent uncorrected visual acuity and maintenance of intraocular pressure control.

Thus, when placing an IOL in an eye with glaucoma following cataract surgery, attention should be paid to the size of the anterior chamber and the previous glaucoma surgeries. Care must be taken to prevent exacerbation of intraocular pressures in eyes that are prone for glaucoma due to the aphakic status and inherent ocular anatomy.

Intraocular Lens Placement in Uveitic Glaucoma

Uveitis causes significant visual impairment as chronic inflammation leads to cataracts, glaucoma, band keratopathy, synechiae, and macular edema [46–48]. Treatment focuses on suppression of inflammation in order to prevent long-term damage first with local and systemic steroids and second with systemic

steroid-sparing therapy. However, both the inflammation and steroids contribute to cataract formation and increased intraocular pressures [49, 50]. The removal of uveitic cataracts should only be undertaken after preoperative inflammation control has been achieved. In general, there should be at least 3 months without uveitic activity prior to cataract extraction. However, whether an IOL can be placed in uveitis remains unsettled. Although many surgeons now elect to place standard acrylic IOLs, there remains a possibility that the IOL could exacerbate the inflammation inciting further complications. Thus, it is an acceptable practice to leave the eye aphakic, especially in situations of tenuous uveitis control [51–53].

Increased IOP in uveitis is due to multiple mechanisms. Uveitic debris collects within the trabecular meshwork and angle leading to decreased aqueous humor outflow [54–56]. In this situation, a membrane is often removed during angle surgery, rendering goniotomy and trabeculotomy highly successful [3–6]. Chronic inflammation also causes synechiae formation and a closed-angle configuration. In some cases, goniosynechiolysis may be employed to reopen the angle, but in others, either glaucoma drainage device implantation or trabeculectomy is a better option to obtain IOP control [57–66]. It is also important to remember that local steroids needed for inflammation control can raise eye pressure [67–69]. Aggressive use of systemic steroid-sparing therapy in order to taper off of local steroids may be required. Regardless of the mechanism, control of the uveitis is paramount for treating the glaucoma. Any consideration of IOL implantation should occur only following both inflammation and IOP control.

Case 2

The patient is a 20-year-old woman with a history of idiopathic uveitis diagnosed at 4 years of age. Her uveitis was controlled with topical steroids, and she did not require steroid-sparing therapy. She was successfully tapered off of topical steroids at 15 years of age without uveitis recurrence. The patient underwent cataract extraction without IOL placement in both eyes at 5 years of age, and glaucoma was diagnosed at 8 years of age. At 11 years of age, the right eye underwent a trabeculectomy with mitomycin C, which was complicated by a postoperative suprachoroidal hemorrhage. She then underwent two goniotomies of the left eye at 16 and 18 years of age. Her intraocular pressures in her left eye remained uncontrolled, and she was referred for further treatment.

At the time of presentation, the patient's best-corrected visual acuity was 20/100 in the right eye and 20/40 in the left eye. Her aphakic correction was +10.75 in the right eye and +10.00 in the left eye. The intraocular pressures by Goldmann applanation tonometry were 8 mmHg in the right eye and 20 mmHg in the left eye. The patient was on timolol, dorzolamide, brimonidine, and bimatoprost in the left eye and oral acetazolamide. Slit lamp examination showed an avascular, thin, and cystic bleb at the superonasal limbus in the right eye. Both corneas were thin and clear. The anterior chambers were deep and quiet. The eyes were aphakic with synechiae between the iris and the Soemmering ring. Fundoscopic examination showed pale optic nerves with a cup to disc ratio of 0.95 in both eyes. The macula in the right eye lacked a foveal light reflex. The macula, vessels, and retinal periphery of the left eye were normal.

For the increased IOP in the left eye, the patient underwent pars plana placement of a Baerveldt® 350 glaucoma drainage device with concurrent vitrectomy. Following surgery, the patient's intraocular pressure in the left eye ranged from 6 to 10 mmHg off of all glaucoma medications.

At 25 years of age, the patient desired placement of IOLs. Her visual acuity had remained stable. Slit lamp examination showed a stable trabeculectomy bleb superonasally in the right eye and a large bleb over the superotemporal Baerveldt® plate in the left eye. Intraocular pressures by Goldmann applanation tonometry were 12 mmHg in the right eye and 7 mmHg in the left eye on no glaucoma medications. Axial lengths measured 23.6 mm in the right eye and 23.4 mm in the left eye, and keratometry was 42.15 × 44.91 @ 38 in the right eye and 42.74 × 44.40 @ 87 in the left eye. The patient desired a mild myopic target. In the right eye, the Soemmering ring was opened and debulked, and a three-piece acrylic lens was placed in the capsular bag. In addition, a subconjunctival injection of mitomycin C (0.2 mg/ml) was administered posterior to the trabeculectomy bleb, and the bleb was needled to remove surrounding Tenon's encapsulation. In the left eye, the Soemmering ring was opened and debulked, and a three-piece acrylic lens was placed in the capsule.

At final follow-up at 27 years of age, the patient's best-corrected visual acuity was 20/125 in the right eye and 20/40 in the left eye. Her refraction was −2.00 in the right eye and −3.50+1.50 × 105 in the left eye. Intraocular pressures by Goldmann applanation tonometry were 10 mmHg in the right eye and 8 mmHg in the left eye off of all glaucoma medications. Slit lamp examination showed a diffuse, mildly elevated trabeculectomy bleb at the superonasal limbus of the right eye and an elevated bleb over the Baerveldt® plate superotemporally in the left eye. The corneas were clear, and the anterior chambers were deep with no evidence of uveitis. In both eyes, the IOLs were in good position within the capsules (Fig. 22.2a). The optic nerves, retinal nerve fiber layer thicknesses (Fig. 22.2b), and visual fields were stable (Fig. 22.2c).

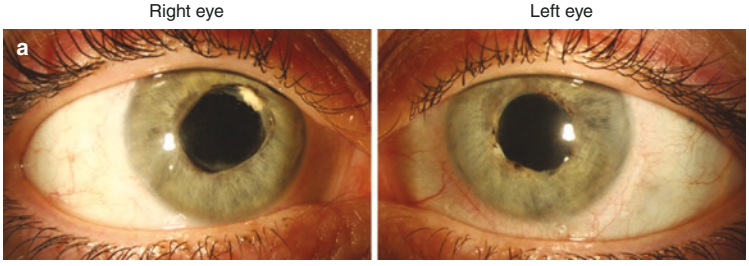
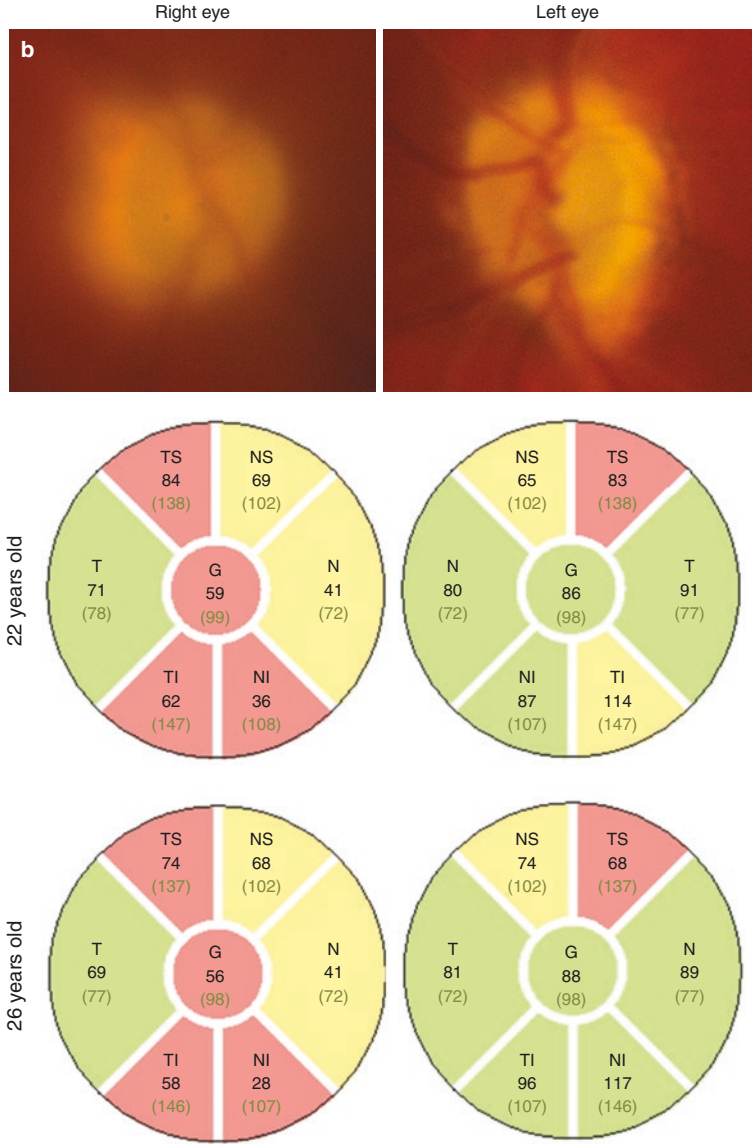


Fig. 22.2 Case 2. (**a**) External photographs of the right and left eyes presented in Case 2 demonstrated IOLs placed within the capsule. There was evidence of synechiae that were lysed with debulking of the Soemmering ring. The superonasal trabeculectomy bleb in the right eye and the superotemporal patch graft in the left eye were covered by the upper lids. The tube in the left eye was in the pars plana and so not evident in the photograph. (**b**) Optic nerve photographs demonstrated pale optic nerves with 0.9 cup to disc ratio in both eyes. Optical coherence testing showed that the retinal nerve fiber layer thickness was stable before and after IOL placement. (**c**) Goldmann visual field testing demonstrated a temporal island with loss of central fixation in the right eye and an inferior arcuate defect in the left eye



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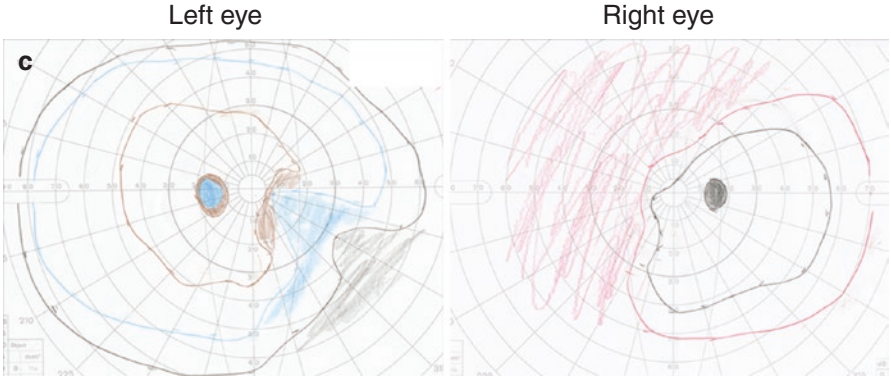

Fig. 22.2 (continued)

Comment Placement of a secondary IOL in an eye with uveitic glaucoma requires inflammation and IOP control. Unlike cataract surgery, which has to be done to improve vision, secondary IOL implantation is elective and should only be pursued if the uveitis has become quiescent [70]. In pediatric cases of uveitis, this typically occurs after puberty and is established when the patient has been successfully tapered off of all steroid and steroid-sparing therapies. Even though the uveitis has been inactive, the patient should be treated with oral steroids for 3–5 days prior to and following surgery to suppress the anticipated higher inflammatory response.

There are additional considerations in uveitic eyes that have undergone glaucoma surgery. Similar to eyes with glaucoma following cataract surgery, in eyes that have undergone angle surgery for uveitic glaucoma, attention should be paid to maintaining the open-angle configuration and cleft patency [3–6]. This includes placement of the IOL within the capsule and treatment with oral and topical steroids to minimize the postoperative inflammation and synechiae formation. The surgeon should be aware that the robust postoperative inflammatory response can result in hypotony, bleb flattening, and subsequent bleb failure. In eyes that have previously undergone trabeculectomy, the incisions for the IOL placement should be placed temporally to avoid injury to the superior bleb. Case 2 illustrated how a subconjunctival injection of mitomycin C posterior to the existing bleb and removal of Tenon's encapsulation tissue are important in preventing postoperative bleb failure. The bleb should be monitored carefully, and additional subconjunctival antifibrotic injections and bleb revisions may be needed to salvage flow through the trabeculectomy and maintain bleb morphology [71, 72]. As stated, in eyes with glaucoma drainage devices, the ideal position for the tube is within the pars plana as placement of the IOL will not interfere with tube function. A previously placed tube within the anterior chamber may be moved posteriorly concurrent with vitrectomy and IOL placement [33]. Although less important in uveitis compared to microphthalmia, posterior placement of the tube prevents corneal decompensation [33–35]. Thus, in uveitic glaucoma, IOLs should be placed within the capsule to

prevent reactivation of inflammation. Additional procedures may be required in eyes, which have had glaucoma surgery, especially trabeculectomies and glaucoma drainage devices.

Intraocular lenses can be safely placed in the setting of glaucoma, but attention needs to be paid to a number of special considerations. The intraocular pressure must be well-controlled prior to IOL placement; this is for preserving vision as well as for accurate lens calculations in young children. In eyes with glaucoma following cataract surgery, the angle and size of the anterior chamber should be evaluated. In uveitic glaucoma, the IOL is ideally placed within the capsule to prevent reactivation of the inflammation. In both of these clinical scenarios, prior glaucoma surgeries may dictate the safest location for the incision for IOL placement, and additional procedures may be required to maintain pressure control. While the goal of lens placement is to improve visual function without contacts or glasses, it is essential that intraocular pressure control not be compromised.

References

1. Sharon Y, Frilling R, Luski M, Campoverde BQ, Amer R, Kramer M. Uveitic glaucoma: long-term clinical outcome and risk factors for progression. Ocul Immunol Inflamm. 2017;25(6):740–7.
2. Groen F, Ramdas W, de Hoog J, Vingerling JR, Rothova A. Visual outcomes and ocular morbidity of patients with uveitis referred to a tertiary center during first year of follow-up. Eye (Lond). 2016;30(3):473–80.
3. Bohnsack BL, Freedman SF. Surgical outcomes in childhood uveitic glaucoma. Am J Ophthalmol. 2013;155(1):134–42.
4. Freedman SF, Rodriguez-Rosa RE, Rojas MC, Enyedi LB. Goniotomy for glaucoma secondary to chronic childhood uveitis. Am J Ophthalmol. 2002;133(5):617–21.
5. Ho CL, Wong EY, Walton DS. Goniosurgery for glaucoma complicating chronic childhood uveitis. Arch Ophthalmol. 2004;122(6):838–44.
6. Wang Q, Wang J, Fortin E, Hamel P. Trabeculotomy in the treatment of pediatric uveitic glaucoma. J Glaucoma. 2016;25(9):744–9.
7. Kwon YH, Kong YXG, Tao LW, et al. Surgical outcomes of trabeculectomy and glaucoma drainage implant for uveitic glaucoma and relationship with uveitis activity. Clin Exp Ophthalmol. 2017;45(5):472–80.
8. Eksioglu U, Yakin M, Sungur G, et al. Short- to long-term results of Ahmed glaucoma valve in the management of elevated intraocular pressure in patients with pediatric uveitis. Can J Ophthalmol. 2017;52(3):295–301.
9. Tan AN, Cornelissen MF, Webers CAB, Erckens RJ, Berendschot TTJM, Beckers HJM. Outcomes of severe uveitic glaucoma treated with Baerveldt implant: can blindness be prevented. Acta Ophthalmol. 2018;96(1):24–30.
10. Sng CC, Barton K. Mechanism and management of angle closure in uveitis. Curr Opin Ophthalmol. 2015;26(2):121–7.
11. Voykov B, Dimopoulos S, Leitritz MA, Doycheva D, William A. Long-term results of ab externo trabeculotomy for glaucoma secondary to chronic uveitis. Graefes Arch Clin Exp Ophthalmol. 2016;254(2):355–60.
12. Law SK, Bui D, Caprioli J. Serial axial length measurements in congenital glaucoma. Am J Ophthalmol. 2001;132(6):926–8.

13. Cronemberger S, Calixto N, Avellar Milhomens TG, et al. Effect of intraocular pressure control on central corneal thickness, horizontal corneal diameter, and axial length in primary congenital glaucoma. J AAPOS. 2014;18(5):433–6.
14. Nakhli FR, Emarah K, Jeddawi L. Accuracy of formulae for secondary intraocular lens power calculations in pediatric aphakia. J Curr Ophthalmol. 2017;29(3):199–203.
15. Kun L, Szigeti A, Bausz M, Nagy ZZ, Maka E. Preoperative biometry data of eyes with unilateral congenital cataract. J Cataract Refract Surg. 2018;44(10):1198–202.
16. 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(8):907–14.
17. Wong IB, Sukthankar VD, Cortina-Borja M, Nischal KK. Incidence of early-onset glaucoma after infant cataract extraction with and without intraocular lens implantation. Br J Ophthalmol. 2009;93(9):1200–3.
18. Chak M, Rahi JS, Group BCCI. Incidence of and factors associated with glaucoma after surgery congenital cataract: findings from the British Congenital Cataract Study. Ophthalmology. 2008;115(6):1013–8.
19. Trivedi RH, Wilson MEJ, Golub RL. Incidence and risk factors for glaucoma after pediatric cataract surgery with and without intraocular lens implantation. J AAPOS. 2006;10(2):117–23.
20. Chen TC, Walton DS, Bhatia LS. Aphakic glaucoma after congenital cataract surgery. Arch Ophthalmol. 2004;122(12):1819–25.
21. Walton DS. Pediatric aphakic glaucoma: a study of 65 patients. Trans Am Ophthalmol Soc. 1995;93:403–13.
22. Michael I, Shmoish M, Walton DS, Levenberg S. Interactions between trabecular meshwork cells and lens epithelial cells: a possible mechanism in infantile aphakic glaucoma. Invest Ophthalmol Vis Sci. 2008;49(9):3981–7.
23. Lam DS, Fan DS, Ng JS, Yu CB, Wong CY, Cheung AY. Ocular hypertensive and anti-inflammatory responses to different dosages of topical dexamethasone in children: a randomized trial. Clin Exp Ophthalmol. 2005;33(3):252–8.
24. Baris M, Biler ED, Yimaz SG, Ates H, Uretmen O, Kose S. Treatment results in aphakic patients with glaucoma following congenital cataract surgery. Int Ophthalmol. 2019;39(1):11–9.
25. Kirwan C, Lanigan B, O'Keefe M. Glaucoma in aphakic and pseudophakic eyes following surgery for congenital cataract in the first year of life. Acta Ophthalmol. 2010;88(1):53–9.
26. Dao JB, Sarkisian SRJ, Freedman SF. Illuminated microcatheter-facilitated 360-degree trabeculotomy for refractory aphakic and juvenile open-angle glaucoma. J Glaucoma. 2014;23(7):449–54.
27. Grover DS, Smith O, Fellman RL, et al. Gonioscopy assisted transluminal trabeculotomy: an ab interno circumferential trabeculotomy for the treatment of primary congenital glaucoma and juvenile open angle glaucoma. Br J Ophthalmol. 2015;99(8):1092–6.
28. Kjer B, Kessing SV. Trabeculotomy in juvenile open-angle glaucoma. Ophthalmic Surg. 1993;24(10):663–8.
29. Lim ME, Dao JB, Freedman SF. 360-degree trabeculotomy for medically refractory glaucoma following cataract surgery and juvenile open-angle glaucoma. Am J Ophthalmol. 2017;175:1–7.
30. Yeung HH, Walton DS. Goniotomy for juvenile open-angle glaucoma. J Glaucoma. 2010;19(1):1–4.
31. Chang I, Caprioli J, Ou Y. Surgical management of pediatric glaucoma. Dev Ophthalmol. 2017;59:165–78.
32. Pakravan M, Esfandiari H, Yazdani S, et al. Clinical outcomes of Ahmed glaucoma valve implantation in pediatric glaucoma. Eur J Ophthalmol. 2019;29(1):44–51.
33. Ozgonul C, Besirli CG, Bohnsack BL. Combined vitrectomy and glaucoma drainage device implantation surgical approach for complex pediatric glaucomas. J AAPOS. 2017;21(2):121–6.
34. Elshatory YM, Gauger EH, Kwon YH, et al. Management of pediatric aphakic glaucoma with vitrectomy and tube shunts. J Pediatr Ophthalmol Strabismus. 2016;53(6):339–43.

35. Bannitt MR, Sidoti PA, Gentile RC, et al. Pars plana Baerveldt implantation for refractory childhood glaucomas. J Glaucoma. 2009;18(5):412–7.
36. DeBry PW, Perkins TW, Heatley G, Kaufman P, Brumback LC. Incidence of late-onset bleb-related complications following trabeculectomy. Arch Ophthalmol. 2002;120(3):297–300.
37. Waheed S, Ritterband DC, Greenfield DS, Liebmann JM, Sidoti PA, Ritch R. Bleb-related ocular infection in children after trabeculectomy with mitomycin C. Ophthalmology. 1997;104(12):2117–20.
38. Cantor AJ, Wang J, Li S, Neely DE, Plager DA. Long-term efficacy of endoscopic cyclophotocoagulation in the management of glaucoma following cataract surgery in children. J AAPOS. 2018;22(3):188–91.
39. Tooke F. Dislocation of the ring of Soemmering, its removal. With some notes on its pathology. Br J Ophthalmol. 1933;17(8):466–76.
40. Suwan Y, Purevdorj B, Teekhasaenee C, Supakontanasan W, Simaroj P. Pseudophakic angle-closure from a Soemmering ring. BMC Ophthalmol. 2016;17(16):91.
41. Kung Y, Park SC, Liebmann JM, Ritch R. Progressive synechial angle closure from an enlarging Soemmering ring. Arch Ophthalmol. 2011;129(12):1631–2.
42. Gimbel HV, Venkataraman A. Secondary in-the-bag intraocular lens implantation following removal of Soemmering ring contents. J Cataract Refract Surg. 2008;34(8):1246–9.
43. Nihalani BR, Vanderveen DK. Secondary intraocular lens implantation after pediatric aphakia. J AAPOS. 2011;15(5):435–40.
44. Koch CR, Kara-Junior N, Serra A, Morales M. Long-term results of secondary intraocular lens implantation in children under 30 months of age. Eye (Lond). 2018;32(12):1858–63.
45. Vinod K, Panarelli JF, Gentile RC, Sidoti PA. Long-term outcomes and complications of pars plana Baerveldt implantation in children. J Glaucoma. 2017;26(3):266–71.
46. Holland GN, Stiehm ER. Special considerations in the evaluation and management of uveitis in children. Am J Ophthalmol. 2003;135(6):867–78.
47. Paroli MP, Spinucci G, Liverani M, Monte R, Pezzi PP. Uveitis in childhood: an Italian clinical and epidemiological study. Ocul Immunol Inflamm. 2009;17(4):238–42.
48. de Boer J, Wulffraat N, Rothova A. Visual loss in uveitis of childhood. Br J Ophthalmol. 2003;87(7):879–84.
49. Sung VC, Barton K. Management of inflammatory glaucomas. Curr Opin Ophthalmol. 2004;15(2):136–40.
50. Kanski JJ. Juvenile arthritis and uveitis. Surv Ophthalmol. 1990;34(4):253–67.
51. Angeles-Han S, Yeh S. Prevention and management of cataracts in children with juvenile idiopathic-arthritis associated uveitis. Curr Rheumatol Rep. 2012;14(2):142–9.
52. Blum-Hareuveni T, Seguin-Greenstein S, Kramer M, et al. Risk factors for the development of cataract in children with uveitis. Am J Ophthalmol. 2017;177:139–43.
53. Mehta S, Linton MM, Kempen JH. Outcomes of cataract surgery in patients with uveitis: a systemic review and meta-analysis. Am J Ophthalmol. 2014;158(4):676–92.
54. Ladas JG, Yu F, Loo R, et al. Relationship between aqueous humor protein level and outflow facility in patients with uveitis. Invest Ophthalmol Vis Sci. 2001;42(11):2584–8.
55. Toris CB, Pederson JE. Aqueous humor dynamics in experimental iridocyclitis. Invest Ophthalmol Vis Sci. 1987;28(3):477–81.
56. Peretz WL, Tomasi TB. Aqueous humor proteins in uveitis. Immunoelectrophoretic and gel diffusion studies on normal and pathological human aqueous humor. Arch Ophthalmol. 1961;65:20–3.
57. Vuori M-L. Molteno aqueous shunt as a primary surgical intervention for uveitis glaucoma: long term results. Acta Ophthalmol. 2010;88(1):33–6.
58. Papadaki TG, Zacharopoulos JP, Pasquale LR, Christen WB, Netland PA, Foster CS. Long-term results of Ahmed glaucoma valve implantation for uveitic glaucoma. Am J Ophthalmol. 2007;144(1):62–9.
59. Ozdal PC, Vianna RNG, Deschenes J. Long-term results of Ahmed glaucoma valve implantation for uveitic glaucoma. Am J Ophthalmol. 2006;144(1):178–83.

60. O'Malley Schotthoefer E, Yanovitch TL, Freedman SF. Aqueous drainage device surgery in refractory pediatric glaucomas: II. Ocular motility consequences. J AAPOS. 2008;12(1):40–5.
61. O'Malley Schotthoefer E, Yanovitch TL, Freedman SF. Aqueous drainage device surgery in refractory pediatric glaucomas: I. Long-term outcomes. J AAPOS. 2008;12(1):33–9.
62. Netland PA, Walton DS. Glaucoma drainage implants in pediatric patients. Ophthalmic Surg. 1993;24(11):723–9.
63. Kafkala C, Hynes A, Choi J, Tpalkara A, Foster CS. Ahmed valve implantation for uncontrolled pediatric uveitic glaucoma. J AAPOS. 2005;9(4):336–40.
64. De Mata A, Burk SE, Netland PA, Baltazis S, Christen WB, Foster CS. Management of uveitic glaucoma with Ahmed glaucoma valve implantation. Ophthalmology. 1999;106(11):2168–72.
65. Carreno E, Vallaron S, Portero A, Herraras JM, Maquet JA, Calonge M. Surgical outcomes of uveitic glaucoma. J Ophthalmol Inflamm Infect. 2011;1(2):43–53.
66. Beauchamp GR, Parks MM. Filtering surgery in children: barriers to success. Ophthalmology. 1979;86(1):170–80.
67. Nuyen B, Weinreb RN, Robbins SL. Steroid-induced glaucoma in the pediatric population. J AAPOS. 2017;21(1):1–6.
68. Gupta S, Shah P, Grewal S, Chaurasia AK, Gupta V. Steroid-induced glaucoma and childhood blindness. Br J Ophthalmol. 2015;99(11):1454–6.
69. Sihota R, Konkal VL, Dada T, Agarwal HC, Singh R. Prospective, long-term evaluation of steroid-induced glaucoma. Eye (Lond). 2008;22(1):26–30.
70. Magli A, Forte R, Rombetto L, Alessio M. Cataract management in juvenile idiopathic arthritis: simultaneous versus secondary intraocular lens implantation. Ocul Immunol Inflamm. 2014;22(2):133–7.
71. Mercieca K, Drury B, Bhargava A, Fenerty C. Trabeculectomy bleb needling and antimetabolitic administration practices in the UK: a glaucoma specialist national survey. Br J Ophthalmol. 2018;102(9):1244–7.
72. Than JYL, Al-Mugheiry TS, Gale J, Martin KR. Factors predicting the success of trabeculectomy bleb enhancement with needling. Br J Ophthalmol. 2018;102(12):1667–71.