Cataract surgery in the small eye

Richard S. Hoffman, MD, Abhay R. Vasavada, MS, FRCS, Quentin B. Allen, MD, Michael E. Snyder, MD, Uday Devgan, MD, Rosa Braga-Mele, MD, FRCSC, for the ASCRS Cataract Clinical Committee, Challenging/Complicated Cataract Surgery Subcommittee

The surgical management of cataract in the small eye presents the ophthalmic surgeon with numerous challenges. An understanding of the anatomic classification in addition to a thorough preoperative assessment will help individualize each case and enable the surgeon to better prepare for the obstacles that might be encountered during surgery. Small eyes are especially challenging in terms of intraocular lens (IOL) calculations and possible current limitations of available IOL powers, which could necessitate alternative means of achieving emmetropia. Surgical strategies for minimizing complications and maximizing good outcomes can be developed from knowledge of the anatomic differences between various small-eye conditions and the pathologies that may be associated with each. A thorough understanding of the challenges inherent in these cases and the management of intraoperative and postoperative complications will ensure that surgeons approaching the correction of these eyes will achieve the best possible surgical results.

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One of the more challenging surgeries for the anterior segment surgeon is cataract extraction and intraocular lens (IOL) implantation in the small eye. This begs the question of what constitutes a "small eye." The parameters for diagnosing a small eye include axial length (AL), corneal diameter, and anterior chamber depth (ACD). The spectrum encompasses a short AL with or without a coexisting small corneal diameter and, at times, with or without a shallow anterior chamber.

Approaching cataract surgery in the small eye requires an appropriate preoperative classification and anatomic assessment to best prepare for the challenging variables that may be associated with the microphthalmic eye. Small eyes are more challenging in terms of IOL calculations, surgical access, and intraoperative complications. In addition, the microphthalmic eye differs from routine eyes in having a higher incidence of postoperative issues that require vigilant follow-up and intervention.

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From the Casey Eye Institute, Oregon Health and Science University (Hoffman), Portland, Oregon, USA; Iladevi Cataract & University of Cincinnati (Snyder), Cincinnati, Ohio, USA; Jules Stein Eye Institute, UCLA School of Medicine (Devgan), Los Angeles, California, USA; University of Toronto (Braga-Mele), Toronto, Ontario, Canada.

Corresponding author: Richard S. Hoffman, MD, 1550 Oak Street, Suite 5, Eugene, Oregon 97401, USA. E-mail: rshoffman@finemd.com.

CLASSIFICATION

The clinical spectrum of the small eye varies from simple microphthalmos, complex microphthalmos, nanophthalmos, and relative anterior microphthalmos (Figure 1).[1–6]

Microphthalmos is an eye with a short AL. Microphthalmic eyes are divided into simple and complex based on the presence of ocular anatomic malformations. Simple microphthalmos is an eye with a short AL and no other ocular malformations. The AL is more than 2 standard deviations (SDs) smaller than normal for the age group. Historically, it is been reported as shorter than 20.5 mm in adults and shorter than 17.8 mm in children younger than 1 year of age. Epidemiologic studies have more accurately defined this number as shorter than 21.0 in adults.[7] These eyes are hyperopic but have a normal ACD and normal scleral thickness. There is no risk for angle-closure glaucoma (ACG) in these eyes. Complex microphthalmos is an eye with a short AL and ocular

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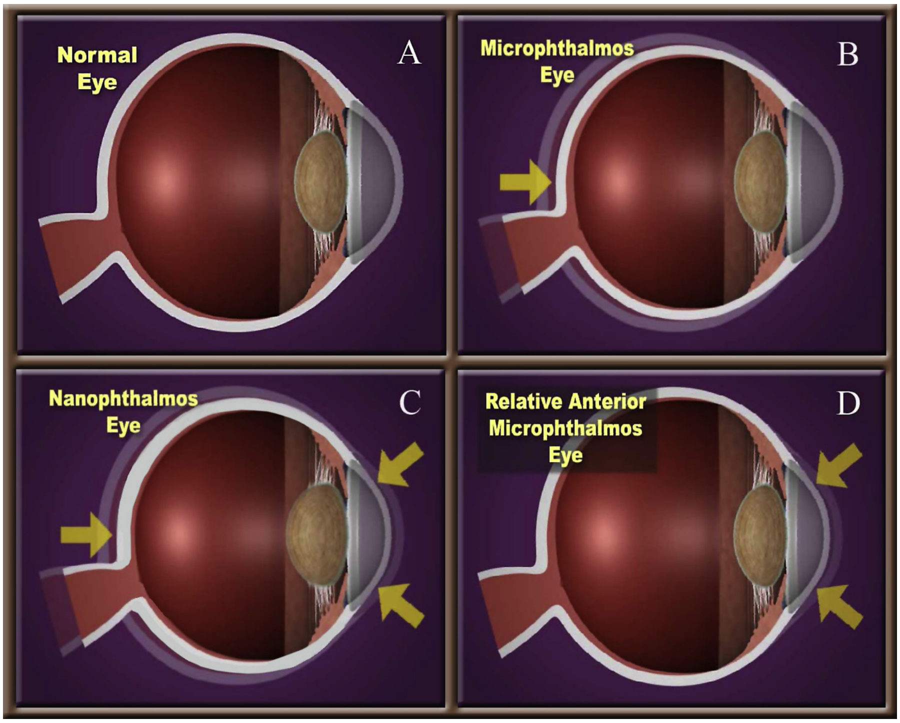

Figure 1. Representation of variants of small eye comparing the AL, ACD, sclera, and lens. *A*: Eye with normal parameters. *B*: Simple microphthalmos with shortened AL. *C*: Nanophthalmos with shortened AL, small anterior segment, thickened sclera, and enlarged lens. *D*: Relative anterior microphthalmos with small anterior segment (ACD = anterior chamber depth; AL = axial length).

anatomic malformations. As in simple microphthalmos, the AL is more than 2 SDs shorter than normal for the age group. In addition, these eyes have coexisting marked ocular anatomic malformations such as iris coloboma, chorioretinal coloboma, persistent fetal vasculature, and retinal dysplasia. They also have a normal scleral thickness.

Nanophthalmos is a rare condition in which the eye has a short AL along with a small anterior segment and thickened choroid and sclera.[2,8] There is currently no consensus on what AL value corresponds to nanophthalmic definitions; values range from shorter than 20.5 mm,[9] 20.0 mm,[10] 18.0 mm,[3] and 17.0 mm.[11] These eyes have a shallow ACD, iris convexity with narrow angles, and normal or increased lens thickness but a propensity for uveal effusion due to the thickened sclera and choroid, usually greater than 1.7 mm posteriorly.[9] They may also have associated microcornea with a diameter shorter than 11.0 mm.[8,12] Microcornea can be seen in simple microphthalmos (Figure 2), complex microphthalmos, nanophthalmos, and relative anterior microphthalmos.

Relative anterior microphthalmos is an eye with a normal AL but a small anterior segment. These eyes have an AL longer than 20.5 mm, but the ACD is equal to or less than 2.2 mm and the corneal diameter, shorter than 11.0 mm.[5,13] They do not have ocular anatomic malformations and have a normal scleral thickness. They are often underdiagnosed before cataract surgery due to their normal AL. There is a high incidence of narrow-angle glaucoma, corneal guttata, and pseudoexfoliation.

In addition to the above conditions, posterior microphthalmos is an extremely rare condition, typically autosomal recessive, in which the eyes have normal anterior segment dimensions but have shortening of the posterior ocular segment and resultant high hyperopia.[14,15] Retinal folds and/or pigmentary retinopathy may be seen, and there is a

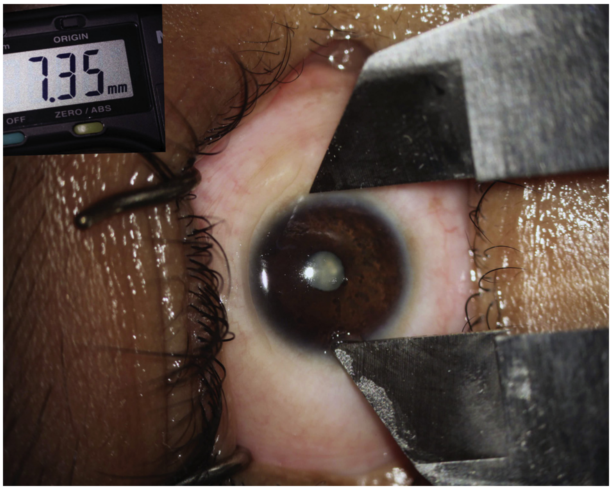

Figure 2. Microcornea demonstrated with digital calipers in an eye with simple microphthalmos and mature cataract.

propensity for uveal effusion.[6,15] These eyes also have sclerochoroidal thickening.

PREOPERATIVE ASSESSMENT

Measurement of corrected visual acuity and refractive status is a necessary part of preparation for cataract surgery. In the patient with an anatomically small eye, the refractive error is most often hyperopia. Significant differences in visual acuity in the presence of similar degrees of cataract may provide a clue to the presence of amblyopia, which is a common finding in the hyperopic eye. If there is a large degree of anisometropia, which may have preceded any refractive shift due to cataract, suspicion of amblyopia should be high.[16] A relatively small amount of anisohyperopia, 1.0 diopter (D) or greater, may result in amblyopia.[17,18] Uncorrected anisohyperopia of more than 4.0 D causes amblyopia in 100% of cases.[19]

The patient with an advanced cataract and a small eye may present with minimal refractive error, or even some degree of myopia, if there has been a myopic shift due to the advanced nuclear sclerosis. Therefore, evaluation of the oldest pair of glasses or previous records may help determine the true amount of preexisting hyperopia. Patients should be queried as to the corrected acuity that they recall and whether this was equal between eyes. It is important to identify preexisting amblyopia to set appropriate expectations for visual recovery and to establish candidacy for presbyopia-correcting IOLs.

Biometry

Assessment of accurate AL, keratometry, and other biometric measurements is paramount to achieving an accurate refractive result in the axial hyperopic eye. A small error in AL measurement will result in a larger refractive error in the patient with a small eye. In this setting, the most accurate method of obtaining AL should be used—partial coherence interferometry (IOLMaster, Carl Zeiss Meditec AG) or optical low-coherence reflectometry (OLCR) (Lenstar, Haag-Streit AG). Partial coherence interferometry has demonstrated the capability of obtaining reproducible measurements to within 20 μm, which is 5-fold better than ultrasound biometry (UBM).[20] Low-coherence reflectometry has also been shown to provide this degree of accuracy and is considered biometrically equivalent.[21,22] Additionally, OLCR provides lens thickness measurements, which are required for newer IOL power calculation formulas, such as the Holladay 2 and Olsen formulas. Even with careful biometry, refractive outcomes may be affected by lens manufacturing tolerance variability.[23] In high-power IOL ranges (>30.0 D), which are often required in highly hyperopic eyes, true dioptric power may vary by as much as ±1.0 D according to the manufacturing standards of the International Organization of Standards.[24]

Anterior chamber depth measurement is an important variable in cataract surgery for both IOL calculations and surgical planning. The anterior chamber is typically shallower in the highly hyperopic eye than in the emmetropic eye,[25] with less room for surgical maneuvers. White-to-white (WTW) corneal measurement may indicate microcornea, which may be an associated anomaly in the microphthalmic eye.

Ultrasound biomicroscopy may be a helpful modality in assessing anterior segment proportions and evaluating anatomic variations consistent with nanophthalmos,[26] such as thickened sclera, thought to increase the risk for uveal effusions, as well as a disproportionately large lens in a reduced anterior segment.[2,27]

Associated Comorbidities

The preoperative assessment should include evaluation for associated comorbidities often encountered in the short eye. Gonioscopy or anterior segment optical coherence tomography (OCT) or UBM should be considered if the angle is potentially occludable on slitlamp examination. Along with ultrasonography, anterior segment OCT or UBM may be useful in evaluating scleral thickness. Angle-closure glaucoma may be more frequently noted in the axial hyperopic eye with a cataractous lens. Biometric measurements such as reduced ACD, increased lens thickness, and short AL have been correlated with ACG.[28,29] Fuchs endothelial dystrophy is also more commonly encountered in these patients.[30] Endothelial cell counts, central corneal pachymetry, and careful slitlamp biomicroscopy are advised to document preexisting corneal disease.

The microphthalmic eye may be associated with other congenital anomalies, such as iris or retinochoroidal colobomas. In the microphthalmic eyes, these congenital anomalies should be evaluated carefully.[31] B-scan ultrasound or indirect ophthalmoscopy is helpful in identifying colobomatous microphthalmia. Eyes with complex microphthalmos may be noted to have anterior segment dysgenesis as well.[32]

Preoperative Counseling

Preoperative counseling in the cataract surgery patient with a short eye should be detailed in several areas. It is important to explain the limitations of biometry and IOL calculation formulas to patients with eyes that fall outside normal parameters. This is especially true of the increased potential for errors in IOL calculation in eyes with short ALs.[33] Although many adult microphthalmic eyes can have modern phacoemulsification safely with a low incidence of intraoperative and postoperative complications,[34] an increased risk for complications or the possible need for additional intraocular manipulation should be discussed. The crowded anterior segment and reduced space for surgical maneuvers increases the risk for inadvertent endothelial touch, as well as iris trauma or prolapse. Therefore, a somewhat more prolonged visual recovery due to corneal edema may be expected. A study of cataract surgery in patients with nanophthalmos by Day et al.[33] showed that the risk for complications increased with abnormal preoperative intraocular pressure (IOP) and shorter AL. Patients with nanophthalmos with ALs shorter than 20.0 mm were associated with much higher risk for complications (15- to 21-times increased risk) than patients with ALs longer than 20.0 mm. Intraoperative zonular dehiscence may also be encountered more frequently in these eyes.[35] Carifi et al.[34] evaluated a series of 39 patients with small eyes and found that microphthalmic eyes with associated congenital pathology were at higher risk for a poor visual outcome. Overall, a 10% risk for complications was observed in this series of patients. When AL and scleral thickness criteria substantiate the clinical diagnosis of nanophthalmos,[27] an increased risk for iris prolapse, postoperative cystoid macular edema, aqueous misdirection, prolonged anterior uveitis, suprachoroidal hemorrhage, persistent corneal edema, retinal detachment, and uveal effusions should be noted.[36]

INTRAOCULAR LENS CALCULATIONS

The 3 variables in IOL calculations are the power of the cornea, the AL of the eye, and the effective lens position (ELP). In any eye, the challenge in calculating IOL power is predicting the final position of the IOL based on preoperative measurements. In an eye with a long AL, the ELP is not as critical because a small IOL movement in the anterior–posterior dimension, coupled with the lower-powered IOL used in these axial myopic eyes, alters the final refractive outcome only slightly. However, in an eye with a short AL, the IOL power is typically higher and even a slight change in the ELP can have a significant effect on the refractive results.

Another important consideration is the relative size of the anterior chamber compared with the AL. The IOL power calculations tend to be more accurate in a short eye with a proportionately small anterior chamber than in an eye with a deep anterior chamber. Holladay[37] and Holladay et al.[38] discovered that about 20% of eyes with short ALs had a small anterior segment and were classified as nanophthalmic. The remaining 80% of the short AL eyes had a normal-size anterior segment (Figure 3). Eyes with a shallow ACD tended to have IOL powers of +30.0 D or less, whereas eyes with the normal ACDs could have IOL powers of more than +40.0 D.[39] This finding is fortuitous relative to the potential need for a piggyback IOL to fully correct the refractive power; ie, eyes most likely to require piggyback IOLs are more likely to have room in the anterior segment for 2 IOLs.

The closer the IOL is to the retina, the more a small change in ELP will alter the refractive results. The A-constant used in IOL power calculations depends on many factors, including the type of IOL used, the refractive index of the material, the IOL geometry, the variance of biometric equipment, the surgical technique, and factors that will affect the ELP. For this reason, small eyes with short ALs may be best served by personalizing the A-constant separately for these eyes.

The best IOL power calculation formulas for small eyes are those that will most accurately predict the ELP. The third-generation formulas use only 2 input variables, the keratometric power and the AL, to determine the ELP and the power calculation. Of these, the Hoffer Q tends to be the most accurate when the AL is shorter than 22.0 mm.[40] The fourth-generation formulas use multiple input variables in addition to keratometry and AL measurement. The Haigis requires the ACD, whereas the Holladay 2 requires ACD as well as WTW, lens thickness, refraction, and age. These fourth-generation formulas, in addition to the Hoffer Q, are preferred when doing IOL power calculations in small eyes.[41–45] A recent study by Carifi et al.[23] confirmed the superiority of the Hoffer Q, Holladay II, and Haigis formulas over the SRK/T and SRK II IOL formulas in small eyes.

Intraocular Lens Selection

Inserting a single IOL is preferred in small eyes because there is less room than in an eye with more normal dimensions. There are multiple U.S. Food and Drug Administration–approved IOLs in powers greater than +30.0 D in a variety of platforms,

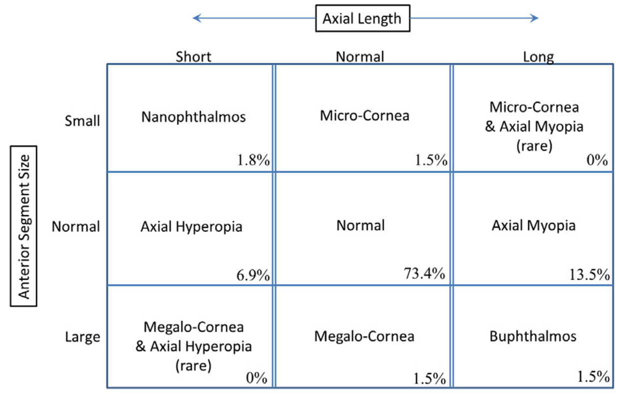

Figure 3. Holladay Schema: 9 types of eyes.

designs, and materials. The Acrysof SN60AT (Alcon Laboratories, Inc.) is a single-piece hydrophobic acrylic IOL that comes in powers up to +40.0 D. When possible, it is preferable to implant a single +40.0 D IOL than to attempt polypseudophakia with two +20.0 D IOLs. In some countries, IOL manufacturers (eg, Carl Zeiss Meditec AG) are able to customize very high-powered IOLs per the physician's orders. This has proven difficult to achieve in the United States and thus other options may be required.

In some small eyes, the power calculations will call for an IOL power of more than +40.0 D and the surgeon must decide how best to correct the refractive error. The options include piggyback IOLs or simply implanting the highest powered IOL available and having the patient use other options to correct the remaining refractive error. If it is a small degree of residual hyperopia, laser vision correction may be possible; the other common options are spectacles or contact lenses.

Piggyback Intraocular Lenses

Piggyback IOLs are an option to increase the refractive power but care must be taken to minimize complications. Primary placement of 2 IOLs in the capsular bag has been associated with interlenticular membranes and opacifications, reduced visual acuity, and a late hyperopic shift.[46–48] The interlenticular membranes are difficult to address with a neodymium:YAG (Nd:YAG) laser, and an additional intraocular surgery is often required to clear this opacification. For these reasons, the current recommendation for a piggyback IOL is to place 1 IOL in the capsular bag and the second IOL in the ciliary sulcus. In the U.S., 3-piece posterior chamber IOLs (PC IOLs) are used in an off-label manner and placed in the sulcus.

There is a debate about which material or combination of materials is best, but many surgeons choose IOLs of different materials. Typically, an acrylic IOL, either 1-piece or 3-piece, is placed in the capsular bag while a 3-piece silicone IOL is placed in the ciliary sulcus with the haptics 90 degrees from the bag IOL haptics. The sulcus-based IOL should be a 3-piece design, with angulated haptics and a rounded edge to minimize damage to the posterior surface of the iris. If the sulcus IOL scrapes the back of the iris, it can result in pigment dispersion, iris transillumination defects, and even uveitis-glaucoma-hyphema syndrome.[49–51]

The available piggyback IOL choices include the AQ-2010 (Staar Surgical Co.), which has an enlarged 6.3 mm silicone optic and a longer length (13.5 mm); the Sensar (Abbott Medical Optics, Inc.), which has a rounded front edge of the optic; and the Li61 (Bausch & Lomb). Intraocular lenses specifically designed and indicated for placement in the sulcus are available outside the U.S. The Sulcoflex (Rayner Intraocular Lenses Ltd.) is a single-piece hydrophilic acrylic IOL with a 6.5 mm optic that has a posterior concave surface and undulating haptics with a 10-degree posterior angulation.[52–54]

The piggyback IOL can be placed at the time of the original cataract surgery or staged later as a secondary procedure. Since IOL power calculations are challenging and less accurate in small eyes, it may be advantageous to do the cataract surgery with implantation of a maximum-powered IOL in the capsular bag and then allow the eye to heal. After the postoperative refractive state has stabilized, the calculation for the piggyback IOL will be more accurate and the surgeon can also determine whether there is sufficient room in the sulcus for the additional IOL. The calculation for the piggyback IOL can be done using the refractive vergence calculation with the Holladay IOL Consultant or it can be estimated using the Gills or Nichamin nomogram.[55] The Nichamin nomogram is a simple method that determines the residual refractive error and multiplies it by 1.5 (for a hyperopic error) to yield the IOL power to be placed in the sulcus. Thus, for a +2.0 D residual refractive error following the primary surgery, a 3.0 D PC IOL would be placed as a piggyback IOL.

Every measure should be taken to protect the capsular bag during phacoemulsification because the options for alternate IOL fixation are limited; there may not be sufficient room for an anterior chamber IOL, and if the primary IOL must be placed in the sulcus, there will likely not be room for a piggyback IOL. Surgeons should learn from the first eye and use that data to hone the IOL calculations for the second eye. As long as both eyes have similar preoperative biometric readings, they are likely to have the same final ELP.

SURGICAL ISSUES

Orbital Anatomy

Orbital anatomy can affect cataract surgery in the small eye. Smaller eyes tend to fill less orbital volume than their larger myopic counterparts. Thus, they may appear to sit deeper in the orbit, making access challenging. Surgeons who prefer to sit superiorly and approach the eye from over the frontal prominence might consider a temporal approach in these eyes. The added benefit of the temporal incision is reflected in the relatively wider horizontal than vertical diameter of the cornea, which, in a small anterior segment, can make a significant difference in access.

Glaucoma

In the presence of narrow angles, glaucoma or elevated IOP should be treated preoperatively with topical medication and/or a peripheral iridotomy. A peripheral laser iridoplasty may also open the angle and lower IOP prior to the cataract removal.

Anesthesia

Although an orbital block may bring the eye forward in the orbit and aid in access, this benefit might be outweighed by the negative impact of an increase in posterior pressure and vortex vein congestion in small eyes, which may already be at risk for uveal effusions. Topical anesthesia has the appeal of preventing orbital congestion; however, the retained function of the extraocular muscles may enhance positive posterior pressure. Still, topical anesthesia is preferable to a block in a cooperative patient if the surgeon is comfortable with this approach.

General anesthesia offers the benefits of reduced orbital volume, absolute akinesia, and reduced posterior pressure from rectus muscle tone but must be weighed against the systemic risk and possible inconvenience. In cases of scleral staphyloma, not uncommonly associated with small eyes, general anesthesia is preferable to a block as colobomatous staphylomas are often located inferiorly, in the area in which an orbital block would be administered.[56] In addition, surgery in children must be performed under general anesthesia.

Intraoperative Considerations

Mitigation of preoperative or intraoperative uveal effusion remains a daunting concern for surgeons.[27,57] Some nanophthalmic eyes can have a low-grade uveal effusion preoperatively. Older literature suggests creating scleral windows to protect against effusions; however, the modern phaco surgeon should be cautious of this recommendation from the era of extracapsular cataract surgeries. In the closed-system phacoemulsification era, a highly pressurized globe is maintained and having a scleral window in which a pressurized intraocular environment is locally contained by uveal tissue only may be unwise. Although currently unreported, some of the authors have seen uveal and vitreous prolapse in this setting.

If scleral windows are created to treat preexisting uveal effusions, it is best to create them several weeks before the cataract procedure. Before performing sclerectomies, an attempt should be made to treat preexisting effusions with cycloplegics, steroids, or both. If uveal effusions develop in a nanophthalmic eye during phacoemulsification, it may be necessary to perform inferior sclerectomies to soften the eye and complete the procedure; thus, it is recommended that surgeons become familiar with the technique before they perform cataract surgery in these eyes.[9] A safer alternative to performing intraoperative sclerectomies in the presence of sudden uveal effusions is to close all wounds and complete the case at a later date, following resolution of the effusion.

Creating the paracenteses and limbal wounds can be different in an eye with a small anterior segment. Often, the corneal pachymetry is thicker than average and if one uses the same angle of entry as with a standard incision, the tunnel length may be longer than anticipated, with a more anterior internal entry than desired. This can make it more difficult to access the lens in an already small space. Attentiveness to the length of the paracentesis incision will help the surgeon compensate for the corneal thickness when creating the primary corneal wound.

Dilation may be suboptimal in small eyes. Even with maximal dilation, in a small anterior segment the pupillary aperture is smaller than usual. Furthermore, these eyes typically do not dilate well and augmentation of the pupillary aperture is often required. In the presence of a small anterior segment with a shallow anterior chamber, iris hooks may be a better option

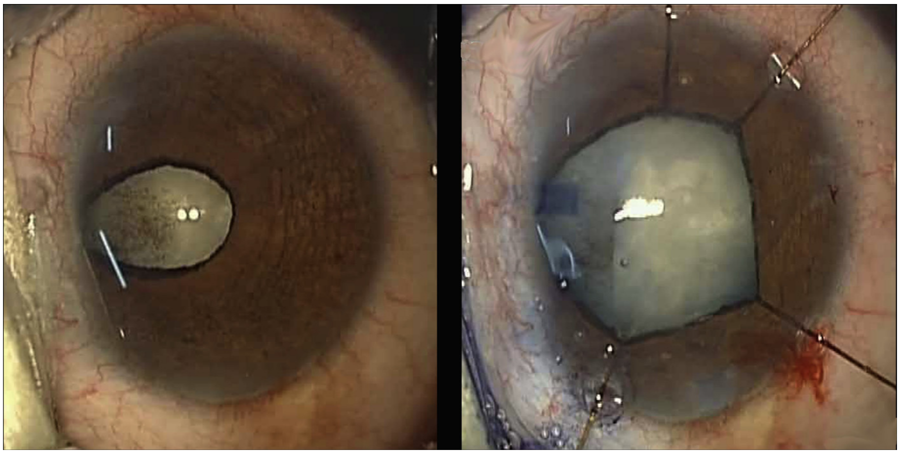

Figure 4. Complex microphthalmos associated with iris coloboma and mature cataract. Eyes such as these may need additional iris hooks for dilation during cataract surgery.

than iris rings due to less likelihood of contacting and damaging the corneal endothelium (Figure 4).

Surgery in eyes with relatively small anterior segments can be hampered by the physical space constraints of these tiny eyes. Especially in nanophthalmic eyes, posterior pressure can compound this challenge, and in some instances surgery in these eyes has been deferred, making the lens likely to be harder and larger. Intravenous mannitol and acetazolamide given 30 minutes preoperatively can reduce vitreous volume[36] and may enable uncomplicated surgery without the need for prophylactic sclerectomies.[58] Gentle orbital massage can further reduce periorbital pressure.

In the most extreme cases, a vitreous tap can create increased chamber depth. The greatest challenge for a limited vitrectomy in these cases is the altered anatomy of the nanophthalmic eye. The pars plana of these eyes may be displaced anteriorly, smaller than usual, or absent. Accordingly, a sclerotomy based on external limbal anatomy could inadvertently pierce the retinal periphery with potentially severe sequelae. A more anteriorly placed blade or trocar could puncture the lens capsule, making the cataract surgery more hazardous.[36] If there is an existing ciliary effusion, the external scleral opening may not line up perfectly with the overlying uveal tissue. If a separate blade is used to create the sclerotomy and the vitrector is then passed through this opening, it could inadvertently enter the suprachoroidal space and increase the detachment or, worse, induce a hemorrhage. Notwithstanding these hazards, sometimes it is necessary to perform a limited vitrectomy to proceed with the case. Attentiveness to technique can mitigate these risks. If a vitreous tap cannot be avoided, a cannula and trocar system will prevent the possibility of entering the supraciliary space because the cannula passes into the eye with the blade and dwells farther internally than the internal uvea. Braga-Mele et al.[A] recommend performing a transconjunctival vitrectomy through a 25-gauge trocar. It is highly recommended that any eye having a pars plana vitrectomy have a thorough evaluation of the peripheral retina following the procedure.

The use of a more highly retentive cohesive ophthalmic viscosurgical device (OVD) can aid in deepening and overpressurizing the anterior chamber for the capsulorhexis, flattening a convex anterior capsule, and thereby reducing the risk for an inadvertent peripheral extension. A microincisional capsulorhexis forceps placed though a paracentesis can prevent inadvertent OVD loss and thus reduce chamber shallowing during this maneuver (Figure 5). An alternative and less expensive option for performing the capsulorhexis is a bent cystotome used through a paracentesis. Trypan blue staining of the anterior capsule may reduce its elasticity and thereby increase the facility and visualization of the capsulorhexis.[59,60] Additional OVD should be added throughout the procedure for more endothelial protection.

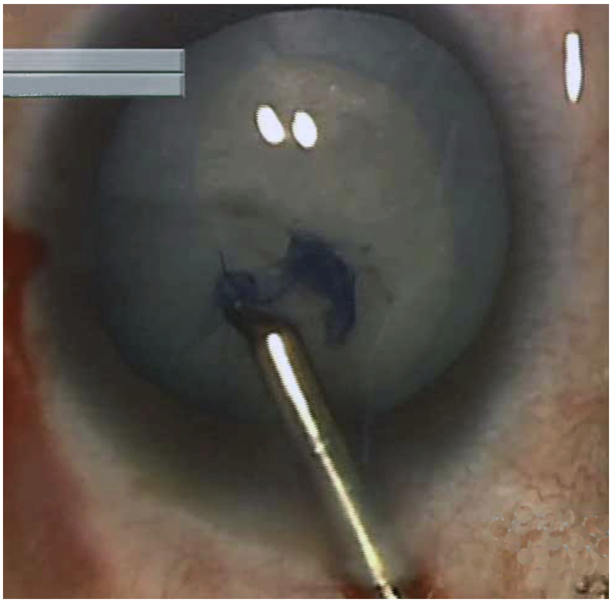

Figure 5. Staining the anterior capsule with trypan blue dye and using a microincision forceps through a paracentesis will facilitate creation of a continuous curvilinear capsulorhexis.

Due to the shallower and smaller anterior chamber, the iris is closer to the internal wound ostium, increasing the odds for iris prolapse. The surgeon may therefore choose to perform the hydrodissection maneuvers through a paracentesis, taking care to allow egress of OVD and fluid by gentle pressure on the posterior aspect of the wound with the hydrodissection cannula. Similarly, the surgeon should remain vigilant when removing instruments from the eye and should stop irrigation just before the phaco handpiece exits the eye. However, during the case, the surgeon should limit pressure fluctuations as much as possible to reduce the risk for uveal effusion or suprachoroidal hemorrhage.

POSTOPERATIVE ISSUES

Residual Refractive Error

The residual refractive error following cataract surgery in small eyes tends to be toward hyperopia, with earlier reports showing an error as high as +7.00 D and more recent reports showing an error of + 0.84 D.[5,36,43,61–63] Jung et al.[61] reported that there was a significant difference between nanophthalmic, microphthalmic, and normal control eyes in the mean numeric errors. Following phacoemulsification, 46% to 66% of the nanophthalmic eyes, 65% to 72% of the relative anterior microphthalmic eyes, and 90%

to 98% of the normal eyes achieved a refraction within ±1.00 D of the refractive aim. Inatomi et al.[63] also reported a tendency toward hyperopia in microphthalmic eyes and found a significant difference in the mean error following cataract surgery between nanophthalmic, relative anterior microphthalmic, and normal control eyes, with less predictability in the nanophthalmic eyes.

Hoffer[43] reported that in eyes with ALs shorter than 22.0 mm, the Hoffer Q and Holladay II formulas performed equally well compared with the SRK/T formula. Carifi et al.[23] reported that 61% of microphthalmic eyes were ±1.0 D from the intended target using the Hoffer Q formula. Auffarth et al.[5] used a biometric formula modified by Haigis for IOL calculation in relative anterior microphthalmic eyes with excellent results. The early postoperative (1 week) refraction was +0.69 D ± 1.45 (SD); after 1 year, the spherical equivalents measured +0.08 ± 2.14 D.

As stated earlier, the treatment of residual refractive errors includes glasses, contact lenses, piggyback IOLs, and corneal refractive surgery. The choice for subsequent refinement of the residual error depends on the patient's expectations and anatomical suitability as well as possible financial considerations for additional elective surgery.

Inflammation Control

Jung et al.[61] reported that anterior segment inflammation was higher in nanophthalmic eyes than in control eyes; however, the difference was not statistically significant between the nanophthalmic, relative anterior microphthalmic, and control groups.

Day et al.[35] reported severe postoperative anterior uveitis in 4 of 103 nanophthalmic eyes, which resolved with topical steroid treatment. Auffarth et al.[5] found fibrin reactions in the anterior chamber in 3 of 62 (4.8%) relative anterior microphthalmic eyes. In another study, 12% of relative anterior microphthalmic eyes demonstrated more than grade 3 flare and cells by the criteria of Hogan; the flare and cells cleared in 2 weeks.[13]

Although small eyes may be more prone to postoperative inflammation, most should respond adequately to increased topical corticosteroids without the need for subconjunctival or oral supplementation.

Atropinization in Microphthalmos

There are no clear-cut guidelines in the literature about the postoperative use of atropine in small eyes to prevent ciliolenticular block. Theoretically, eyes with nanophthalmos could benefit from postoperative atropinization.

Glaucoma Monitoring and Treatment

Small-incision cataract removal techniques have reduced the incidence of complications. Nevertheless, the incidence of glaucoma following phacoemulsification procedures ranges from 4.7% to 46.0% in these groups. Steijns et al.[36] found a considerable risk for ACG after cataract surgery in nanophthalmic eyes; 4.7% of eyes developed elevated IOP and 1 of the eyes required trabeculectomy at 4 weeks.

Jung et al.[61] found that IOP was not well controlled in 2 of 17 eyes (11.7%) with nanophthalmos. One required trabeculectomy at 3 months postoperatively. None of the eyes developed uveal effusion or choroidal hemorrhage intraoperatively or postoperatively.

Wu et al.[9] reported significant complications after cataract surgery in 12 nanophthalmic eyes. The additional surgeries required in these eyes included glaucoma laser treatment (8 eyes), cyclocryotherapy (2 eyes), trabeculectomy with scleral resection (1 eye), trabeculectomy (1 eye), and Nd:YAG laser capsulotomy (4 eyes).

Day et al.[35] reported elevated IOP due to aqueous misdirection from 6 months to 51.7 months postoperatively in 7 eyes of 6 patients (46%) with a short AL (nanophthalmos and microphthalmos). In 2 eyes, misdirection was controlled with a Nd:YAG posterior capsulotomy followed by a Nd:YAG peripheral iridotomy to disrupt the anterior vitreous face. The remaining eyes required cyclodiode laser treatment for IOP control. The authors suggested that performing a surgical iridectomy at the time of phacoemulsification might facilitate laser hyaloidotomy if aqueous misdirection should develop. This may be especially helpful in nanophthalmic eyes, which tend to have thickened irises that are more difficult to penetrate with a Nd:YAG laser. Auffarth et al.[5] reported ciliolenticular block in 7 of 62 eyes (11.6%) with relative anterior microphthalmos that had cataract surgery.

The presence of a shallow or flat anterior chamber following phacoemulsification should raise the suspicion for aqueous misdirection, which can lead to malignant glaucoma. It is important to remember that the IOP is not always elevated initially in patients with aqueous misdirection. Treatment includes the use of topical cycloplegics and steroids and a Nd:YAG laser application to the anterior hyaloid face to attempt to reverse the misdirection. A posterior vitrectomy may also be required but should be used only if other measures fail.[39]

Differentiating aqueous misdirection from secondary ACG resulting from peripheral uveal effusions can be done with UBM.

Uveal Effusion

It has been reported that postoperative uveal effusion can be caused by a sudden decrease in IOP during surgery.[9,64] Recent studies report that it may be rarer than previously thought.[35] It has also been reported that uveal effusion is caused by abnormalities of the sclera and increased resistance to transscleral fluid outflow, in which case subscleral sclerectomy may be an effective treatment.[65]

Steijns et al.[36] found a considerable risk for uveal effusion after cataract surgery in nanophthalmos. Uveal effusion was noted in 9.3% of eyes. In 2 eyes, it developed within weeks of cataract surgery. In 1 eye, it developed after a Nd:YAG procedure. This study included patients having both standard extracapsular cataract extraction and phacoemulsification.

Day et al.[35] reported small choroidal asymptomatic effusions in 3 of 103 eyes with short ALs. The results indicate that small-incision cataract surgery, although challenging, is mostly safe and diminishes the need for prophylactic sclerotomies in these high-risk eyes.

SUMMARY

Fortunately, the majority of small-eye cases that will be encountered in an average ophthalmic practice will constitute simple microphthalmos with a normal anterior segment but shortened AL. These cases usually proceed routinely without intraoperative or postoperative complications.

In the more challenging cases of complex microphthalmos, relative anterior microphthalmos, and nanophthalmos, a thorough knowledge of the anatomic variables, ideal formulas for IOL calculations, and pearls for avoiding and dealing with intraoperative access and complications will help the surgeon approach these cases with more confidence. Delivering the best surgical outcome in small eyes requires a thorough preoperative classification and anatomic assessment, accurate preoperative biometric measurements and IOL calculations, and painstaking attention to surgical technique and postoperative management.

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First author:
Richard S. Hoffman, MD

Casey Eye Institute, Oregon Health and Science University, Portland, Oregon, USA