MANAGING THE SMALL PUPIL

A small pupil increases the likelihood of intraoperative complications and was originally considered by Dr. Charles Kelman to be a contraindication to phacoemulsification. In 1985, Dr. Robert Osher presented a series of small pupil cases that were successfully managed, utilizing a modification of the United Surgical phacoemulsification machine that provided an improvement in fluidics control. Prior to the introduction of this modification, phaco machines had only maximum and minimum settings with a bottle height fixed by a cumbersome rod. Osher introduced a new concept: surgeon-controlled vacuum with continuous irrigation from a bottle of adjustable height, regulated by an automated IV pole. The result of this innovation was a reduction of anterior chamber turbulence and improved stability.

Introducing a technique called slow-motion phacoemulsification, Osher explained that, by lowering parameters, he was able to perform phacoemulsification effectively in spite of poorly dilating pupils. He presented a paper entitled “The GASP Technique” (Golly, Another Small Pupil) at the American Intraocular Implant Society meeting and Dr. Kelman was a discussant. Dr. Kelman agreed that by modifying fluidic behavior and reducing surge, the surgeon could work near the iris with diminished risk of inadvertent iris and capsular damage. This is an approach that has stood the test of time.

Today’s surgeon has a wide range of choices for handling the small pupil. It is the purpose of this chapter to review these different options and also discuss the use of reduced phaco parameters in the management of specific surgical challenges associated with the miotic pupil. The second issue of the 2008 Video Journal of Cataract and Refractive Surgery provides video footage of each of the following categories.

Options for Pharmacologic Dilation

Traditionally, the use of topical mydriatics in the form of a sympathomimetic agent combined with a parasympathetic blocker fulfilled the goal of achieving mydriasis. Adding epinephrine to the balanced salt solution (BSS) infusion has supplemented and maintained dilation. With the introduction of Ocufen (Allergan, Irvine, CA), it was realized that a nonsteroidal anti-inflammatory drug (NSAID) also contributed to maintenance of dilation by blocking the miotic effect of prostaglandins released when the iris was manipulated. A cotton pledget soaked in neosynephrine and placed at the limbus was very effective in achieving maximal dilation but fell out of favor because
of systemic concerns. However, IOL Tech, a French company, introduced Mydriasert, a sustained-release product placed in the inferior fornix. Intracameral mydriatics were introduced by Dr. Björn Lundberg and Dr. Andes Behndig and by Drs. Cionni, Barros, Kaufman, and Osher. The instillation of 1% phenylephrine directly onto the anterior capsule has been found to be helpful in maintaining pupil size in patients with intraoperative floppy iris syndrome (IFIS) by Drs. Monvikar and Allen and Drs. Gurbaxani and Packard. Dr. Joel Shugar advocated “Shugarcaine” using 1:1,000 bisulfite-free epinephrine that is mixed in a 1:3 dilution with three parts BSS+ and one part nonpreserved lidocaine 4%. Approximately 1 mL of this mixture is slowly injected into the anterior chamber before instillation of the ophthalmic viscosurgical device (OVD).

Viscomydriasis With Healon 5

Pupillary dilation can be achieved by the injection of an OVD (viscomydriasis). Healon 5 (AMO, Santa Ana, CA), a high molecular weight sodium hyaluronate OVD, is uniquely capable of dilating and maintaining a wide pupil. By mechanically moving iris tissue toward the angle, Healon 5 is effective in expanding the pupil (Figure 7-1). Moreover, Healon 5 behaves as a highly retentive, semi-solid material that bows the iris posteriorly, resulting in a deeper chamber with additional dilation. Some pupils will enlarge dramatically with Healon 5, while others will dilate less. In virtually all patients, however, Healon 5 produces some useful viscomydriasis, it is often necessary to reinject Healon 5 in order to maintain the effect. This is because either the OVD is aspirated or it escapes through the incision, allowing the pupil to narrow. In order to use Healon 5 most effectively as a viscomydriatic, it is important to understand how to keep the Healon 5 in the anterior chamber.

Healon 5 behaves as a dispersive OVD when the vacuum is less than about 200 mmHg and the aspiration rate is about 25 cc/min or less. If the vacuum or aspiration rate exceeds these levels, the material behaves in a cohesive manner. This unique variable viscoelastic behavior allows the surgeon to keep Healon 5 in the anterior chamber during the phacoemulsification if vacuum and aspiration rates are maintained at low levels, and then remove the OVD material readily at the conclusion of the procedure, using higher vacuum and aspiration settings. Since ultrasonic energy is capable of shattering the tightly packed, long-chained molecules, it is best to avoid anterior chamber emulsification as fractured Healon 5 is less likely to resist aspiration forces. Moreover, if a high bottle height creates a high pressure in the eye, there is a greater likelihood that the Healon 5 will be “forced” either into the aspiration port or out through the incision, especially when the latter is poorly constructed or distorted. (See below for a step-by-step explanation of the use of Healon 5 in IFIS.)

Stretching the Pupil

Cutting or stretching the pupillary sphincter is another method of obtaining a larger pupil during surgery. The use of scissors to create multiple sphincterotomies was popular during the 1990s before Dr. Luther Fry popularized the pupil stretch technique. Pupil stretching is accomplished with two blunt instruments (eg, hooks, collar buttons, retractors, etc). Under the protection of an OVD, the hooks are introduced.
and placed in the same meridian 180 degrees away from one another. The iris is then stretched with each instrument simultaneously toward the angle, momentarily held, and then released (Figure 7-2). A second stretch can be performed 90 degrees away from the first if the surgeon desires. After pupil stretching, when OVD is reinjected, an enlargement of the pupil usually occurs. While small sphincter ruptures are visible at the slit lamp following surgery, the pupil generally retains a physiologic shape and functions normally.

Peripupillary Membranectomy

Another technique involving the pupillary sphincter is peripupillary membranectomy, which Osher described in the early 1980s. In cases of uveitis or chronic pilocarpine usage, the pupil is bound down by synechiae, which prohibit the pupil from dilating. A string-like fibrotic membrane at the border of the pupil can often be stripped, which serves to release the pupil (Figure 7-3).

Iris Hooks

Iris retractors are another option for achieving mechanical dilation. Prior to the introduction of microscopic hooks, surgeons occasionally used a retraction suture or deliberately prolapsed the iris into an incision to achieve a dilatory effect. Later, metal, fine wire, and prolene retractors were introduced by Drs. Mackool, Engels, and deJuan, respectively. Iris hooks may be disposable or reusable and may be anchored by adjustable corks, sliding tabs, or weights. The technique for inserting the iris hooks requires a carefully thought-out plan since tenting the iris toward the cornea should be avoided (Figure 7-4). In cases with a shallow chamber, an instrument introduced through a remote incision may help to usher the hook into position. The surgeon may vary the number of iris hooks as well as the incisions. A recent variant has been introduced by Drs. Oetting and Omphrey. These authors described the placement of a hook below the primary cataract incision, which creates a diamond-shaped pupil for optimal visualization and manipulation of the ultrasound and irrigation and aspiration (I/A) tips. While tiny sphincter ruptures can be observed at the slit lamp following surgery, the pupil usually regains normal size and function. Although some effort and time is
required to place iris hooks, the hooks are very effective in maintaining an enlarged and stable pupil during phacoemulsification.

*Surgical Instruments and Devices for Dilating the Pupil*

A number of devices have been developed that will facilitate pupillary dilation. The first such device was the Beehler dilator, manufactured by Moria (Doylestown, PA), which was composed of three prongs that would mechanically stretch the pupil. The Graether silicone pupil dilator and the Siepser hydrogel tire were designed to mechanically open and maintain the larger pupil. Morcher introduced a plastic incomplete circle (300 degrees) that would allow the surgeon to place this device at the pupil border and the fixed diameter would mechanically enlarge the pupil. The Milverton Perfect Pupil, manufactured by Becton Dickinson (Franklin Lakes, NJ), was a similar design with a small handle. The most recent advance is an injectable ring developed by Dr. Boris Malyugin of Moscow and distributed by MST (Redmond, WA). The closed ring is injected through a small incision and its four scrolls capture and retract the pupil border, maintaining an adequate opening until the device is removed at the conclusion of the procedure (Figure 7-5).

**Managing Challenging Clinical Situations**

*Intraoperative Floppy Iris Syndrome*

Prior to the excellent detective work of Dr. David Chang and Dr. John Campbell linking IFIS with tamsulosin use, surgeons were often mystified by a perplexing group of patients whose pupils did not dilate well and who demonstrated a progressive miosis during surgery. This group of patients also routinely demonstrated a reduction of the iris tone with intraoperative billowing and iris prolapse. Thanks to the efforts of Drs. Chang and Campbell, it is understood now that tamsulosin is a primary cause of iris dysfunction during cataract surgery. IFIS is among the most challenging situations encountered by the cataract surgeon. Healon 5, which can be used to maintain pupil dilation in patients with IFIS, is a very useful tool in the management of these cases.

**Management of Intraoperative Floppy Iris Syndrome, Utilizing Healon 5: A Step-by-Step Approach**

Step 1. *Dilate the Pupil and Stabilize the Iris.* First, with the cannula opening well beyond the incision, inject Healon 5 into the anterior chamber to create viscomydriasis. Simultaneously, the Healon 5 will also displace the iris...
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posteriorly, which helps to prevent iris billowing and prolapse. Iris stretching with instruments is not advised in IFIS, as this may result in a further reduction in the tone. Intracameral phenylephrine or intracameral epinephrine, which tightens the iris diaphragm by stimulating the dilator muscle, may also be used.

Step 2. Use “Slow Motion” Phaco to Disassemble and Emulsify the Nucleus. To use Healon 5 most effectively, phacoemulsification is initiated with the bevel down, buried in the anterior cortex, using an aspiration rate of 25 cc/min and a vacuum of 250 mmHg (Figure 7-6).

Since the tip opening is occluded by cortex below the Healon 5, the OVD is undisturbed as several bursts of ultrasound create a divot in the lens. Fluid exchange can then occur under the Healon 5 without thermal consequences. Before continuing the phacoemulsification, one must make certain that there is fluid movement through the phaco tip, as occlusion of the tip during the emulsification can lead to thermal injury. As soon as the divot in the anterior cortex is deepened to the nucleus, reduce the vacuum to 40 mmHg, rotating the bevel up in order to sculpt safely. Since occlusion does not occur during sculpting, there is not enough aspiration to draw the Healon 5 from the anterior chamber into the exposed port. The Healon 5, therefore, remains undisturbed. Working within the posterior chamber, carefully disassemble the entire nucleus within the capsular bag. Although we prefer a chopping technique, a divide and conquer technique is usually the best approach for the less experienced surgeon. Once the lens is divided into quadrants, the vacuum may be raised to 190 mmHg to facilitate the emulsification of the nuclear fragments. The surgeon should try to emulsify the nucleus within the capsular bag, leaving the Healon 5 undisturbed in the anterior chamber. The settings vary from surgeon to surgeon depending on the height of the table, the phaco machine, the incision size, power modulation, bottle height, type of sleeve, etc. However, once the principles of reduced vacuum and flow are understood and mastered, the surgeon is usually able to retain the Healon 5 and maintain pupillary dilation throughout the phacoemulsification procedure.

Step 3. Removal of Cortex and Healon 5. After phacoemulsification of the nucleus is complete, the cortex and Healon 5 are removed using standard irrigation and aspiration (I/A) and the capsular bag can be inflated with standard Healon or Healon 5. We prefer to use Healon 5 although special care must be taken to remove all of the Healon 5 after the intraocular lens (IOL) implantation. Healon 5 has a high molecular weight and can lead to markedly elevated postoperative intraocular pressures if this material is not removed in its entirety from behind the IOL.

In order to minimize the chance of late iris prolapse, the incision should be hydrated before inserting the I/A. After IOL implantation and removal of OVD from the capsular bag, intracameral myochol is injected to constrict the pupil. The combination of a hydrated small incision and a pharmacologically constricted pupil acts to reduce the tendency for iris prolapse.

Uveitis

Any previous inflammation may result in a bound down, small pupil with posterior synechiae between the iris and the lens. Separating the visible adhesions is often only the “tip of the iceberg” since the iris may also be adherent to the lens more peripherally. Occasionally, there is obvious retraction of the iris or retroillumination defects that may indicate extensive fibrosis, in which case visco separation or blunt dissection is necessary.
Management of Iris Synechiae: A Step-by-Step Approach

Step 1. Analyze the Extent of Pupillary Fibrosis and Lens to Iris Synechiae. Place Healon 5 in the anterior chamber to provide viscosydriasis as described above. Look for evidence of restricted dilation of the pupil and locate areas of adhesions of the iris to the lens capsule.

Step 2. Use Mechanical Measures to Open the Pupil, if Necessary. If there is evidence of pupillary fibrosis which prevents the dilation of the pupil with Healon 5, the surgeon may attempt to grasp the pupil margin with a micro-forceps and then with light traction, determine whether a peripupillary membrane is present. On occasion this membrane can simply be removed, freeing the pupil. If this is unsuccessful, the pupil should be stretched mechanically. Healon 5 should be utilized again in an effort to dilate the pupil. If an adequate pupil size cannot be obtained after these maneuvers, iris hooks may be employed as described above.

Step 3. Use Healon 5 and Blunt Dissection, if Necessary, to Lyse Iris to Lens Synechiae. Lyse the synechiae at the pupillary border frequently can be accomplished with the Healon 5 cannula. More extensive fibrosis may require visco separation or blunt dissection. Subincisional adhesions may be separated with either a “J-shaped” cannula through the primary incision, a sweeping maneuver with the Healon 5 cannula from the side port, or an iridotomy may be performed to allow the introduction of either a spatula or the OVD cannula for viscodissection.

Whenever there is evidence of old intraocular inflammation, especially when the iris has undergone significant surgical manipulation, pericocular steroids and NSAIDs, as well as topical steroids, should be considered to prevent excessive postoperative inflammation and synechial recurrence.

Pseudoexfoliation

In pseudoexfoliation, careful preoperative biomicroscopy reveals the powdery white material that may or may not be present in the classic tri-zonal distribution. A weakness of zonules is associated with pseudoexfoliation, but in most instances, it is the small pupil that creates the greatest potential for intraoperative complications. Suboptimal dilation associated with pseudoexfoliation is fortunately not accompanied by either iris atonicity or iris synechiae, and the Fry pupil stretch technique is usually very effective in creating pupillary dilation.

Pseudoexfoliation: A Step-by-Step Approach

Step 1. Dilate the Pupil Using Pupillary Stretching. After filling the chamber with Healon 5, two dull Y-hooks or collar button hooks are introduced, one through the main incision and the other through a side-port incision. Alternatively, two side-port incisions may be utilized. The tips of the hooks are advanced until the pupil margin is engaged in the same meridian but on opposite sides of the pupil. The distal hook is advanced while the proximal hook is retracted. The pupil is stretched and held in a stretched position for a moment. Care should be taken not to damage the anterior lens capsule. The hooks can be repositioned in a meridian 90 degrees away for an additional stretch if desired.

Step 2. Use “Slow-Motion” Phacoemulsification to Disassemble and Emulsify the Nucleus. Once the pupil has been stretched, the injection of Healon 5 will further widen the pupil. Slow-motion phacoemulsification with lowered parameters offers the best strategy to retain the Healon 5 and maintain dilation in cases of pseudoexfoliation. The technique for using Healon 5 with slow-motion phacoemulsification is the same as with IFIS. (See the above description of the use of slow-motion phacoemulsification, under the discussion of IFIS.) Should the surgeon encounter any signs of significant zonular weakness, he or she should be familiar with the use of iris/capsular retractors to stabilize the lens bag as well as a capsular tension ring (see Chapter 14, Capsular Tension Rings), which has greatly improved the management of this serious complication.

White or Brunescent Cataract

The mature cataract is often associated with a poorly dilating pupil. Even when the pupil dilates to 5 mm, the presence of a white or an extremely brunescent cataract compromises visualization of the anterior capsule. This reduced visualization makes the creation of a continuous curvilinear capsulotomy very difficult. With mature lenses, visualization of the anterior capsule is greatly facilitated by the use of capsule dyes,
such as indocyanine green, introduced by Horiguchi et al., and trypan blue, first described by Melles et al.

Staining the anterior capsule with these dyes can be accomplished by a number of different techniques, but we prefer a three-step method utilizing Healon 5.

**Capsule Staining, Utilizing Healon 5: A Step-by-Step Approach**

**Step 1. Place Healon 5 over the Anterior Capsule.** Healon 5 is injected into the anterior chamber, being careful not to overfill it. Healon 5, which is highly retentive under conditions of low flow, provides a very stable chamber for intraocular manipulation.

**Step 2. Create a Space Between Healon 5 and the Anterior Capsule.** Inject BSS directly onto the anterior capsule, elevating the Healon 5 into the corneal dome while creating a thin layer of fluid directly over the anterior capsule.

**Step 3. Inject Capsular Staining Dye Into the Supracapsular Space.** Trypan blue is then placed into the thin BSS-filled space. This results in an even stain of the anterior capsule without creating an “ink blot” in the anterior chamber or forcing dye under pressure through the zonules into the vitreous cavity. The Osher dye cannula (Storz [Bausch & Lomb, San Dimas, CA] and Crestpoint Management [St Louis, MO]) has the port on the posterior surface of the cannula that allows the dye to be delivered precisely onto the anterior capsular surface. It may be necessary to inject additional BSS or Healon 5 to gain optimal visualization before proceeding with the capsulorrhexis.

**Small Pupil Associated With Iridodialysis**

Rarely, the anterior segment surgeon will encounter a traumatic cataract associated with extensive iris disinsertion. Depending upon the extent of the damage, the pupil may appear miotic and eccentric. The iris must be reattached to the sclera by a series of nonabsorbable horizontal mattress sutures. Following the repair of the iridodialysis, the use of iris hooks or pupil-expanding devices may be helpful if pharmacologic dilation still fails to achieve an appropriate pupil size.

**Summary**

Dr. Charles Kelman, the father of phacoemulsification, alerted his disciples to the perils of operating upon the cataract patient with a small pupil. For many years, the small pupil was one of Dr. Kelman's contraindications to phacoemulsification. Fortunately, advances in machine technology, viscosurgery, surgical techniques, and devices for mechanical dilation have made operating within the small pupil far more safe and compatible with an excellent visual outcome.

**References**

