Cataract extraction by the extracapsular method requires an opening of the anterior capsule. Before Charles Kelman’s development of phacoemulsification, when standard extracapsular surgery was performed routinely, the capsule was opened with a multi-jaw forceps, pinching it until it tore from both sides. Typically, an Aruga forceps was used (Figure 3-1). As large an opening as possible was ideal because the lens nucleus was then expressed from the capsular bag into the chamber and out of the incision. Kelman described a more controlled opening using a blunt cystotome, creating a triangular tear (the so-called “Christmas tree” tear) starting from the 6 o’clock position of the pupil (Figure 3-2). The torn capsular tag was pulled out of the superior incision and cut off, creating a triangular opening (Figure 3-3). The triangular opening technique was then modified with additional tears (Figure 3-4), and eventually the “can opener” technique evolved with multiple tears placed in a circular fashion. This technique helped to reduce the risks of engagement of the capsular flaps during phacoemulsification and cortex removal because the multiple small tears resulted in smaller capsular flaps (Figure 3-5). The mechanical stress on the margin of the can opener capsulotomy, caused by sculpting and manipulation of the nucleus, however, sometimes resulted in the radial extension of one of the small tear notches. These tears then extended to the periphery of the capsule and “zipped” around the equator, resulting in a posterior capsular tear. As phacoemulsification techniques progressed from anterior chamber emulsification to in-the-bag disassembly of the nucleus, manipulation within the capsular bag increased and the need to develop a more tear-resistant opening in the anterior capsule became increasingly critical. The development of a continuous circular capsular tear technique, which came to be called continuous curvilinear capsulorhexis (CCC), greatly increased the safety of cataract surgery. Highly resistant to the development of radial tears, CCC greatly reduced the risk of intraoperative posterior capsular tears and paved the way for the development of a variety of lens disassembly techniques, which also increased the safety of phacoemulsification. CCC also increased the ability of surgeons to place both loops of an intraocular lens (IOL) within the capsular bag more reliably and, because the circular capsular opening helped to ensure symmetrical capsular contraction forces, the technique helped to obtain and maintain better centration of the IOL.

After its introduction, CCC gradually became adopted by ophthalmic surgeons because of its clear advantages. The technique, however, is not as easy to
perform as the can opener technique. The successful performance of a complete curvilinear tear is one of the most difficult maneuvers of cataract surgery. Although the development of improved ophthalmic viscoelastic devices and the use of capsular staining techniques have helped to facilitate the performance of CCC, the risk of losing control of the tear and allowing it to extend to the equator, combined with the difficulties of making the capsulotomy both central and of an optimum size, is a constant challenge for every surgeon.

There are many ways to fashion a CCC. Some surgeons begin with a cystotome to start and then complete the CCC with a capsule forceps (Figure 3-6). Some use a cystotome alone to complete the entire circular tear. Others use a forceps to puncture the capsule and then complete the tear with the forceps. Some surgeons tear in a counterclockwise direction and others a clockwise direction. The Kraff-Utrata capsulorrhexis forceps is the most commonly used (Figure 3-7). A number of modifications and variations of the basic Kraff-Utrata design are available that the surgeon may choose from. Standard capsulorrhexis forceps require at least a 2.5-mm incision to work through. If one works through smaller incisions for microincisional, coaxial, or bimanual phacoemulsification, micro-forceps, usually 20-gauge, designed for vitreoretinal work or for small corneal incisions, may be used (Figure 3-8).

The choice of an ophthalmic viscoelastic device (OVD) significantly affects the performance of capsulorrhexis. At zero shear, higher molecular weight, cohesive OVDs, such as Healon GV or Healon 5 (AMO, Santa Ana, CA) or DisCoVisc (Alcon, Fort Worth, TX), are better at maintaining space than are lower molecular weight, dispersive OVDs. Dispersive
Capsulorrhexis

OVDs, such as Healon D (AMO) and Viscoat (Alcon), offer more coating and provide more protection for the corneal endothelium during phacoemulsification, but when there is no fluid movement in the eye (zero shear), these OVDs are more runny and less retentive than are the higher molecular weight OVDs. A cohesive, highly retentive OVD provides the most flattening of the anterior capsule and the most stable anterior chamber during capsulorrhexis. It is more difficult, however, to pull the torn flap of tissue through a highly cohesive OVD. Using these viscoelastics, care is required when tearing the capsule with the forceps or cystotome. One must be careful not to allow the tear to turn centrally, as this tends to make an opening smaller than desired. With these highly retentive viscoelastics, however, it is easier to prevent the tear from radializing. This allows for the performance of a safe capsule opening in more challenging cases such as eyes with very shallow chambers, loose or missing zonules, children’s cataracts, and in lenses that are mature and intumescent.

Figure 3-4. Kelman’s triangular opening technique progressed to a few tears with small flaps.

Figure 3-5. The can opener capsulotomy.
These higher molecular weight OVDs are particularly helpful when opening the capsules of young people and children where the lens material is soft and the capsule is very elastic. With a cohesive, high molecular weight viscoelastic, one is able to flatten the anterior capsule and equalize the pressure on each side of the capsule. A flat capsule rather than a dome allows for a more controlled CCC opening. In addition, these high molecular weight viscoelastic materials are helpful with intumescent cataracts. Surgeons have long known that emptying of the capsular bag of soft cloudy liquid material through a small opening prior to CCC makes the procedure more controllable. Before stains such as trypan blue (Vision Blue, Dutch Ophthalmic, Exeter, NH) were available, surgeons performed this aspiration technique when the lens material was mostly liquid but completely white and under a lot of pressure. This approach should be kept in mind for special situations such as a rapidly developing traumatic cataract and for fibrotic anterior capsules that require cutting with micro-scissors (Figure 3-9). The fibrosis may be better visualized after soft cortical material has been aspirated, a red reflex obtained, and more viscoelastic has been added.

**Step-by-Step Approach to Continuous Curvilinear Capsulorrhexis**

Step 1. **Select the Optimal OVD(s) for the Specific Case.** As noted previously, cohesive high molecular weight OVDs provide optimal flattening of the anterior lens capsule and are better at chamber maintenance than are dispersive, low molecular weight OVDs. In cases of extremely dense cataracts, or if an endothelial dystrophy
exists, a dispersive OVD may be used to coat the endothelium for increased protection, and then a more retentive, cohesive OVD may be used to fill the anterior chamber for capsulorrhexis.

Step 2. **Begin the Tear Centrally and Create a Capsular Flap.** Once the anterior chamber is filled with viscoelastic, the capsule is punctured centrally with a sharp bent cystotome needle or a sharp capsule forceps and the tear guided away from the center in a direction that will enable the surgeon to easily grasp the developing flap with the forceps. This may be just a vertical tear away from or toward the incision or a curving tear that is directed radially to the desired diameter of the CCC. The tear is then continued in a circumferential direction to create a flap edge. Using the forceps or additional OVD under the flap, elevate the flap vertically into the anterior chamber to make it easier to grasp with forceps.

Step 3. **Grasp the Flap and Begin the Curvilinear Tear.** Once the flap is elevated, grasp the flap with the forceps and continue the circular, or at least curvilinear, tear until it is complete. When performing capsulorrhexis, the flap must be regrasped or reengaged a few times to control the direction of the tear. The more difficult the direction of the curvilinear tear is to control, the more frequently the flap must be released and regrasped. Each time the flap is released, be sure to elevate the flap edge in order to make the flap easier to grasp again.

Step 4. **Optimize Control of the Tear.** Control of the direction of the tear is optimized when the flap is regrasped near the point of tearing. The flap is then folded on itself, and a shearing technique is used to better direct the tear. Tearing the capsule by simply pulling the capsule centrally gives the surgeon less control of the direction of the tear. Folding the capsule over itself, moreover, causes less stress on the zonular ligament and prevents the capsule from shifting from a tug on the zonules while the tear is fashioned. Such a shift can result in an eccentric opening in the capsule or one that is larger than desired. In routine cases this shearing technique can be combined with direct tearing for some portions of the circle. When direct tearing is used, one has to be aware of vector forces and watch the point of tearing rather than the point of the forceps. The vector force required to direct the tear appropriately varies as the tear progresses around the circle. The capsule is more elastic and less “brittle” in young eyes, and the direction of the force of the forceps is usually quite radial centripetally or toward the center of the pupil. It is sometimes necessary to pull in a direction 90 degrees from the direction of the tear. In these eyes it is important to release frequently to verify the diameter of the tear as the zonules and the capsule are so elastic. It is also very important to regrasp every 1 or 2 clock hours to keep control of the direction and diameter of the tear.

**Additional Points of Importance**

The ideal diameter of the capsular opening is now widely believed to be about 5 mm. This allows the CCC rim to cover the edge of the 6-mm IOL optic. Nishi and Nishi have shown that there is less fibrous opacification of the posterior capsule postoperatively if the margin of the anterior capsule rim does not touch the posterior capsule.\(^5\) This also makes it important to make the capsular opening as central as possible and not too oval or outside of the diameter of the optic in any meridian.

In 2005, Tassignon et al of Belgium introduced a newly designed ring caliper to facilitate the sizing and centration of the CCC along the alignment of the first and third Purkinje reflexes as observed under the microscope.\(^6\) Most surgeons do not have this device available and simply make their best effort to center the CCC and to make it of an optimal size. Some surgeons place a ring mark on the cornea with a zone marker to assist in sizing and placement of the CCC.\(^2\)

If the CCC ends up too small or is eccentric, a technique that I have described as “two-staged CCC” may be considered to enlarge it or make it more round. This technique may also be used to start a tear going in the opposite direction from one that has radialized or to convert a small can opener opening to a CCC (Figure 3-10). To start a new tear in the edge of an existing opening, a scissor is used to make a very short tangential cut. The new beginning flap is then grasped with forceps and the new tear is continued around the circle of desired diameter (Figure 3-11). If this new start needs to be in the subincisional area, one may have to make another capsule puncture with a sharp needle or cystotome to start a new tear. Angled vitrectomy scissors may be used as well for unusual situations.
Careful placement of a cohesive viscoelastic under and over the capsule is necessary to safely start the new tear.

A capsule with a fibrotic zone or an entirely fibrotic anterior capsule presents a challenge. If the fibrosis is just a band in a quadrant easy to reach with a scissors, one may cut through the band with the scissors. An elegant technique is to use a Fugo blade instrument (Medisurg Research and Management, Norristown, PA) which cuts with a plasma field around a fine filament. This device cuts with ease through fibrosis as well as normal capsule and can be used to enlarge CCCs or manage uncontrolled capsule tears. The device is also useful in the management of traumatic openings in the anterior capsule that cannot be safely handled with scissors and forceps.

Posterior continuous curvilinear capsulorrhexis (PCCC) may also be performed. The same principles apply when creating an opening in the posterior capsule as in the anterior capsule. When opening the posterior capsule, one may decide to not prevent forward movement of the vitreous because a vitrectomy is planned and thus take no precautions to protect it. If, however, one wishes to avoid a vitrectomy and protect the vitreous, it is important to start the PCCC with a hooking snag rather than a cutting puncture. A small snag may be created using the barbed end of a disposable 27-gauge hypodermic needle. This small barb may be made by pressing the tip of the needle on the handle of a needle driver or forceps until a very small, right angle bend is made in the tip. Once the opening is made, the vitreous is pushed back with additional viscoelastic through the opening. The tearing is then continued and additional viscoelastic is added intermittently to keep viscoelastic under the capsule where the flap of capsule is being regrasped. The size of the PCCC should be at least 3 to 4 mm for a good-sized opening that will always be clear of secondary cataract, except in children where cells use the intact vitreous face as a scaffold and occlude the visual axis; in this case, when the technique of PCCC optic capture is planned, the opening should be about 4.5 mm (Figure 3-12). Openings larger than this may not capture the haptic optic junctions tightly enough to prevent lens epithelial cells from migrating behind the IOL to opacify the visual axis by depositing new lens material on the intact vitreous face (Figure 3-13). If the opening is smaller than 4.5 mm, and thus too small for optic capture, the two-stage technique may be used to enlarge it just as with the anterior capsule.

The PCCC may be used for access to the vitreous cavity for a number of indications such as the removal...
of silicone oil, reduction of asteroid hyalosis, for anterior vitrectomy and antibiotic injection in cases of presumed postoperative endophthalmitis, and to prevent secondary cataract by preemptively opening the posterior capsule. Capsular dyes may be helpful when doing PCCC, especially when there is a poor fundus reflex, as with asteroid hyalosis and endophthalmitis. Indications for PCCC in order to prevent secondary cataract include severe kyphosis and socioeconomic barriers to Nd:YAG laser capsulotomy.

Openings in the posterior capsule may be made many years after primary surgery. This may be indicated when IOL removal and replacement or IOL repositioning is needed and membrane optic capture is planned to fix the IOL to the capsular membrane. If there is no fibrosis in a 4- to 5-mm zone of the capsular membrane, the opening may be made with the tearing techniques described above. If there is fibrosis present or the single posterior layer of capsule is not large enough for a desired 4- to 5-mm opening, the Fugo blade or scissors would have to be used with increased risk of disturbing the vitreous and of extension of the tear by the force required to get optic capture.

In secondary surgery for improved fixation, repositioning, or removal and replacement of an IOL, another fixation technique to utilize for fixation of the IOL to the capsule is capsular membrane suture fixation. In this technique the haptics of the IOL are sutured to the fibrotic elements of the capsular membrane to fix the IOL to the capsular membrane rather than leave it loose in the sulcus to erode iris pigment, erode iris vessels, and potentially become eccentric (Figure 3-14).

REFERENCES

6. Tassignon MJ, Rozema JJ, Gobin L. Ring-shaped caliper for better anterior capsulorrhexis sizing and centration. J Cata-