The Ideal Capsulotomy

Efforts to create a precise and reproducible capsulorhexis.

BY KEVIN GAMETT, MD; LEONARD K. SEIBOLD, MD; JEFFREY R. SOOHOO, MD; AND MALIK Y. KAHOOK, MD

The method for creating an anterior capsulorhexis has changed considerably over time, and surgeons continue to refine their approach with novel techniques and innovative technologies. Introduced in the 1980s by Gimbel and Neuhann,[1] the continuous curvilinear capsulorhexis (CCC) increased the strength of the capsulotomy, which, in turn, improved the stability of the implanted IOL. Although the CCC remains the gold standard for modern cataract surgery, the technique can be challenging to execute in cases of zonular instability, poor pupillary dilation, shallow anterior chambers, corneal scarring with a hazy view, and hypermature cataracts associated with positive pressure on the capsule. Creating a centered capsulotomy of a precise size can be especially difficult for surgeons in training,[2] and there is a lack of consensus regarding the best and safest way to create the ideal capsulorhexis. Various instruments and devices have been developed to facilitate the creation of a capsulotomy.

TRADITIONAL METHOD

After filling the anterior chamber with viscolelastic, most surgeons begin the capsulotomy by creating a small incision in the anterior capsule with a cystotome. Next, they manually advance the resulting capsular flap into a circular shape by guiding the leading edge with the cystotome. Alternatively, surgeons may pull the capsular flap in a circular fashion by grasping the leading edge with a forceps and advancing the tear with frequent regrasping. A Utrata forceps is most commonly used for this step, but a Duet forceps (MicroSurgical Technology), which is designed to be effective through a sub-2-mm incision is becoming more popular (Figure 1).

Oftentimes, surgeons center the capsulotomy by using Purkinje reflexes as a guide. The capsular opening should have a diameter smaller than that of the IOL's optic, which is generally 6 mm. Too small a capsulorhexis may make nuclear disassembly difficult, place considerable stress on the zonules during nuclear removal, and promote postoperative capsular phimosis. Too large a capsulorhexis may allow the IOL's optic and haptics to dislocate anteriorly out of the capsular bag, which might lead to imprecise effective lens positioning and could damage sulcus tissues.

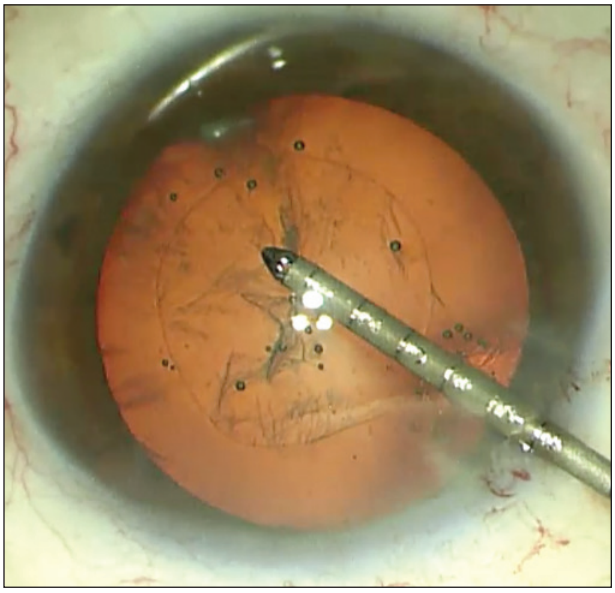

Figure 1. With the Duet forceps, the surgeon can perform delicate maneuvers through small incisions.

Refractive outcomes are influenced by the centration and size of the capsulorhexis. A properly sized and well-centered capsulotomy with 360º of anterior capsule-optic overlap reduces the risk of optic decentration, IOL tilt, myopic shift, and posterior capsular opacification.[3-6] Okada and colleagues demonstrated that a capsulotomy decentered by more than 0.4 mm was associated with a 0.25 D change in spherical equivalency and that an incomplete capsulorhexis-optic overlap was associated with 0.50 D of induced astigmatism 1 year postoperatively.[7]

IN PURSUIT OF PRECISION

Surgeons and industry continue to strive to create instruments and devices to improve the accuracy of the capsulorhexis. The Fujimoto 5.3-mm CCC Guide (Crestpoint Management) and the Ota 5.6-mm CCC Marker with Center Pointer (Crestpoint Management)

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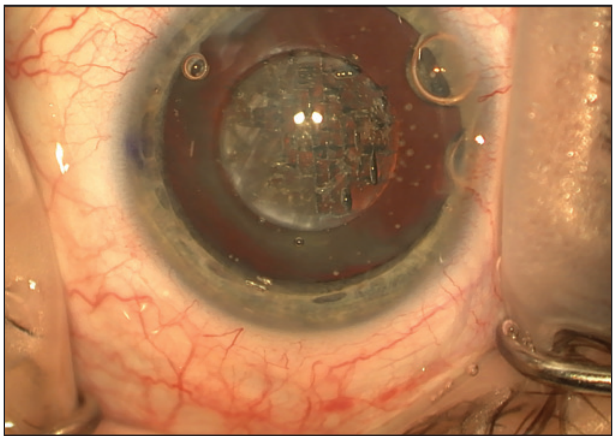
are designed to help surgeons create precisely sized and shaped capsulotomies. The Verion Image Guided system (Alcon) and Callisto Eye (Carl Zeiss Meditec) project a circular template of predetermined size on the anterior capsule intraoperatively. Prior to the introduction of these advanced systems, Samuel Masket, MD, filed a patent proposing a system that would allow surgeons to configure a target image to be projected and tracked using sensors during the creation of the capsulotomy (http://bit.ly/1vPVke3). Another embodiment proposed by the same patent uses a physical template that can be inserted into the anterior chamber to make an impression in or mark on the lens capsule.

Surgical devices designed to provide a visual guide on the anterior capsule have also been developed. The Raviv Capsulorhexis Caliper (Bausch + Lomb) has blunt, adjustable marking tips that indent the anterior capsule on two axes after they are inserted through the main cataract incision. The Confetti Caliper (Morcher), introduced in 2003, was a soft ring that could be inserted and placed on top of the anterior capsule, and trypan blue dye could then be injected into the ring. The resultant stained area on the anterior capsule served as a template for the surgeon during capsulorhexis formation. Unfortunately, the device did not work well and appears to have been abandoned by the inventors. The Morcher Ring Caliper (Morcher; distributed in the United States by FCI Ophthalmics) is a sterile, temporary polymer ring placed directly on top of the anterior capsule. After aligning the ring, the surgeon creates the capsulotomy while staying away from the inner margin of the ring. To facilitate the device's insertion through a small incision, another visual aid was recently designed: an incomplete PMMA ring 5.3 mm in diameter.[8]

Some devices physically alter tissue to achieve a desired outcome. The Fugo Plasma Blade (Medisurg Research & Management) and the Pulsed Electron Avalanche Knife (Medtronic) have both been used to effectively and safely create a capsulotomy.[9,10] Bausch + Lomb developed a device that applies electromagnetic induction heating to create a precisely sized and centered capsulorhexis (http://bit.ly/1nc7KOd). A primary conducting coil external to the eye projects magnetic field lines into a secondary conducting coil that has been placed onto the anterior capsule. The surgeon tears along the resultant burn line to create the capsulorhexis. Clinical data on this device are not currently available. Mynosys Cellular Devices is developing a device that automates capsulorhexis formation by applying suction to the anterior capsule, and a mounted cutting element incises the anterior capsule along that template (http://bit.ly/1vPXoCK).



(Courtesy of John Berdahl, MD.)

Figure 2. Femtosecond lasers can create a precisely sized capsulorhexis, segment the lens, and perform corneal incisions.

THE ERA OF LASER SURGERY

Laser cataract surgery holds great promise for creating predictably sized, well-centered anterior capsulotomies, even in eyes with zonular instability and hypermature lenses (Figure 2). Numerous studies have demonstrated that capsulotomies created with the laser are more precise in terms of size, centration, and postoperative IOL alignment compared with manual capsulotomies.[11,12] Other studies suggest that improved centration and morphology do not affect refractive outcomes.[13] Furthermore, an investigation using scanning electron microscopy showed that capsulotomies made with a laser resembled a micro-can opener with a zippered or jagged edge.[14] These small perforations are likely the result of fixational eye movements during laser treatment. One multicenter study reported a 16-fold increase in radial tears after laser-assisted capsulotomy compared to manually created CCCs.[14] This finding has raised questions regarding the integrity of laser-assisted capsulotomies, and further longitudinal studies are needed to assess whether the microperforations will have long-term adverse effects on patients'

A SILICONE RING FOR CAPSULOTOMY CREATION

By Robert J. Cionni, MD

For the past 3 decades, the continuous curvilinear capsulorhexis (CCC) has been the gold standard for creating a capsulotomy. Several devices have been introduced to replace the CCC, but unlike other devices, the Verus (Mile High Ophthalmics) is designed to enhance the accuracy and reproducibility of the CCC rather than replace it.

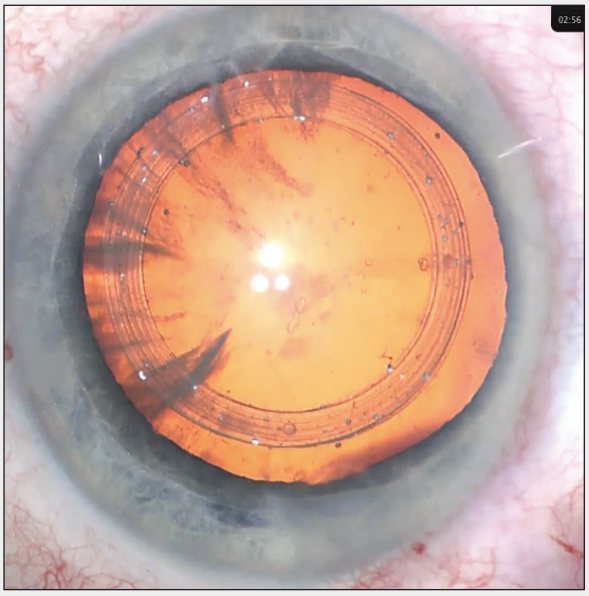


Figure 1. The Verus device firmly adhered to the anterior capsule with viscoelastic. The device is centered on the microscope light filament reflex with the patient fixated between the two large coaxial light sources.

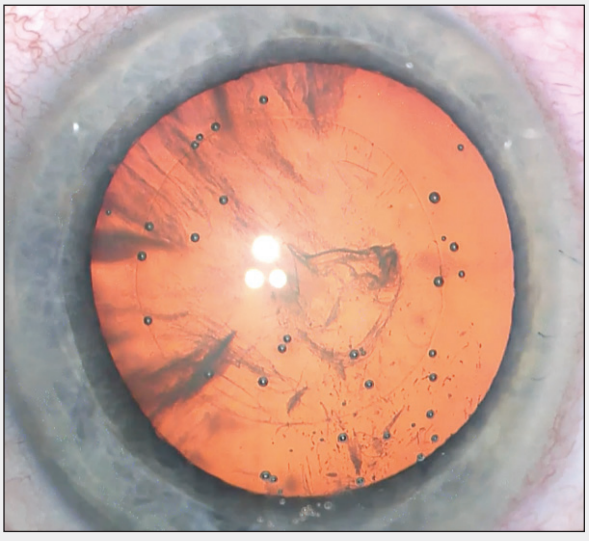


Figure 2. A nicely sized and centered capsulorhexis after using the Verus device.

The Verus is a biocompatible silicone ring. It has an outer diameter of 6.2 mm and an inner diameter of 5 mm (Figure 1). The ring is inserted prior to the capsulotomy's creation and is removed immediately after this step. In my experience, the device's unique design makes it ideal for improving the consistency of the anterior capsular opening. A micropatterned surface acts as a braking system once the device is placed on the capsule so that the ring maintains stability and limits side-to-side movement. A distinct angle to the inner edge of the ring enhances my ability to walk the anterior capsular flap along the inner diameter of the device for precise creation of the capsulotomy. I can position the device over the light reflex prior to initiating the capsulorhexis. The final result is a CCC that is precisely sized and positioned as I wish (Figure 2).

I find the advantages of the Verus to be significant. The device can be cost-effectively integrated into the natural flow of cataract surgery. I had no need for expensive hardware and additional surgical steps prior to entering the OR, and I was able to customize the position of the capsulotomy in real time under direct view of the microscope. In my experience, the Verus is also well suited to residents and fellows during training, and the device can help novice surgeons perfect the capsulorhexis technique, which is one of the most important factors in a successful cataract procedure.

Potential drawbacks to the device include a minimal increase in cost and procedural time. I have found that the best results with the device require the use of a capsulorhexis forceps rather than a cystotome, which some surgeons might be more accustomed to using.

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> "Marking the cornea, projecting light onto the anterior capsule, and inserting a presized device into the anterior chamber may help the surgeon by providing visual aids to correctly and reproducibly size and center the capsulorhexis."

outcomes. It should be noted that many surgeons who perform laser cataract surgery have not experienced problems with tags or rents that might be due to variability between lasers. The improvements that are being made to the various laser platforms also appear to be enhancing outcomes of capsulotomies when compared to the manual CCC technique.[15]

Despite the promise of femtosecond laser-assisted capsulotomies, the cost of laser technology will likely prevent surgeons from transitioning entirely away from manual capsulotomies, especially in developing countries. A unique aspect of laser-assisted capsulotomies is that the same laser can be used to perform corneal incisions and segment the lens, something that the previously discussed devices are unable to accomplish. As the laser platforms become more versatile in ophthalmic surgery, including for glaucoma and retina surgery, the cost of buying the machine may become more economically feasible for practices around the world.

MOVING FORWARD

The progression from the can opener technique to the CCC was a major advance that led to innovations in the procedure and IOL design. To perfect the precision of this difficult maneuver, many devices have been patented, although few have made it to market for general use. Marking the cornea, projecting light onto the anterior capsule, and inserting a presized device into the anterior chamber may help the surgeon by providing visual aids to correctly and reproducibly size and center the capsulorhexis. Visual aids still involve a significant amount of imprecision, however, because they do not inherently assist with the formation of the capsulorhexis. Thermal, electromagnetic, and mechanical cutting instruments have not seen wide adoption due to cost and a decrease in the integrity of the capsulorhexis compared to that of the manual CCC. The recent introduction of the femtosecond laser could improve the predictability and precision of the capsulotomy, although the increased cost and alteration in OR flow still present obstacles to wide adoption. One thing is certain, ophthalmologists and industry members will continue to develop new ways to assist surgeons of all experience levels to perform a precisely sized and centered capsulorhexis. ■

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