The Basics of Phacoemulsification

Step-by-step advice for a successful cataract procedure.

BY ROGER F. STEINERT, MD

Consistently successful phacoemulsification begins with preoperative planning. The key surgical steps are (1) anesthesia, (2) prepping, draping, and the microscope's setup, (3) the incision, (4) the capsulorhexis, (5) nuclear disassembly, (6) cortical cleanup, (7) implantation of the IOL, and (8) closure of the incision. Postoperative management is the final critical element in a successful outcome.

PREOPERATIVE PLANNING

A comprehensive examination determines whether the density of the cataract is consistent with the patient's visual complaints. It also identifies comorbidities. For example, finding corneal guttae mandates the added steps of measuring pachymetry and obtaining specular microscopy, discussing the risks, and planning for intraoperative protective measures for the endothelium. Nuclear opalescence can be underappreciated unless the nucleus is viewed through a dilated pupil with a thin slit beam and all filters off. Because most cataract surgery is indicated to improve visual function, a careful ocular and medical history must be taken.

If cataract surgery is in the patient's best interest, the surgeon must identify the type of IOL that meets the patient's needs. Measurements of corneal curvature and axial length are used to compute the power of the IOL. Beyond that basic testing, a surgeon needs to determine which IOL calculation method is the most reliable (axial length's being the biggest variable affecting the formula) and, by tracking his or her results, to refine a surgeon-specific IOL factor.

For patients with significant astigmatism and/or desiring spectacle independence with a lifestyle IOL, corneal topographic imaging is advisable. Many people have irregular corneas due to unsuspected conditions including forme fruste keratoconus or keratitis sicca. Some surgeons will also routinely obtain a macular optical coherence tomography scan to identify subtle pathology such as an epiretinal membrane.

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The documents available to the ophthalmologist at the time of surgery must include all of the pertinent elements identified during the preoperative evaluation, including notation of the location of the steep meridian and the amount of cylinder. Finally, the surgeon must have a plan for the use of antibiotics, nonsteroidal anti-inflammatory drugs, and dilating agents, both immediately before surgery and in the days preceding surgery. In some cases, extra measures are indicated for comorbidities such as blepharitis or keratitis sicca.

ANESTHESIA

With current microsurgery, the most common type of anesthesia is topical. Many surgeons apply a viscous anesthetic agent in order to achieve a deeper numbing than can be obtained with standard anesthetic drops. Because the viscous agent will interfere with the desired bactericidal action of povidone-iodine, the former should be applied well in advance of or after the latter.

Factors negatively affecting the patient's ability to cooperate (eg, physical, mental, emotional, or linguistic challenges) may influence the choice of a retrobulbar or peribulbar injection of anesthetic, intravenous sedation, or general anesthesia. Sometimes, simply taping the patient's forehead to the headrest permits safe surgery.

PREPPING, DRAPING, AND THE MICROSCOPE'S SETUP

If a toric IOL or astigmatic incision is planned, and if the surgeon will not use an adjunctive device to determine the
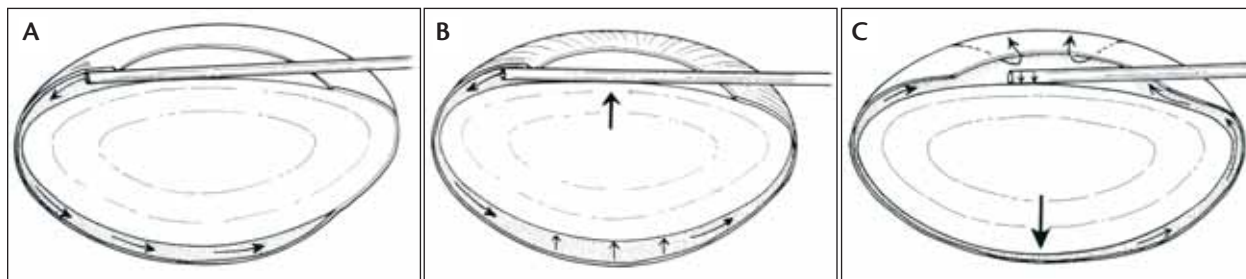
Figure 1. Successful hydrodissection begins with generating a fluid wave that will pass around the equator and dissect the posterior nucleus from the posterior cortex (A). The fluid begins to elevate the nucleus toward the surgeon (B). The surgeon should press posteriorly on the nucleus to express the fluid from behind and around the equator, thus further loosening the nucleus (C). (Reprinted with permission from Steinert RF, ed. *Cataract Surgery*. 3rd ed. London: Saunders Elsevier; 2010.)

rotational position of the eye, he or she marks the cornea with gentian violet ink while the patient is upright. Once he or she is supine, the eye may cyclorotate up to 15°.

Currently, most surgeons prepare the skin, eyelashes, and ocular surface with povidone-iodine solution (not soap) unless an allergy requires an alternate agent. Draping should isolate the eyelashes and meibomian glands from the surgical field, because they are impossible to sterilize fully.

Effective draping can be a challenge with topical anesthesia and a patient who squeezes his or her eyelids despite instructions. Because of this problem and variable orbital anatomy, the tray of surgical instruments should include multiple styles of lid specula, including those for both nasal and temporal placement as well as triple-post and solid blade designs.

The microscope's oculars should be examined to match the pupillary distance and any refractive error of the surgeon. Once the microscope is placed over the patient, the light source must be aligned with the eye to obtain an excellent red reflex.

At the start of the case, an oil slick or waxy debris floating on top of the irrigating fluid used to keep the cornea moist represents a warning sign of potential bacterial contamination. Copious irrigation is needed to remove the debris. Rather than waste time and a large amount of balanced salt solution from the small squirt bottle, it is more efficient to use the irrigating flow from the phaco handpiece. This will lift the oils up and off the surgical field quickly and thoroughly.

THE INCISION

The location of the incision may be constrained by factors such as orbital anatomy and the seating limitations imposed on the surgeon. A temporal incision is common, due to the advantages of easy access between the eyelids and a slightly greater distance of the temporal limbus from the pupillary center.

The incision slightly flattens the cornea in that meridian.

Surgeons can use that effect by orienting the incision on the steep meridian whenever possible.

A clear corneal or perilimbal incision is more likely to be watertight the closer its configuration becomes to a square. The keratome blade must be angled to control the entry point through Descemet's membrane in order to achieve this shape.

THE CAPSULORHEXIS

The continuous curvilinear capsulorhexis is the foundation on which successful phacoemulsification rests. The strength of the continuous curve allows maneuvers that would otherwise result in "wrap-around" tears, and the well-defined borders permit reliable fixation of the IOL within the capsular bag. Many teachers of cataract surgery believe that a well-centered and properly sized capsulorhexis is the most difficult step in the procedure. Beginners should practice tearing stretched cellophane-type food-wrap material and the skin from fruits such as tomatoes and grapes. Trypan blue can improve visualization of the capsule and is useful for beginning surgeons as well as in eyes with dense cataracts. Commercial surgical simulators, if available, may also be helpful. Some ophthalmologists use virtual image devices in the microscope, direct marks on the cornea, or flexible rings in the anterior chamber to guide the size and shape of the capsulorhexis.

The size of the capsulorhexis plays a role in the effective lens position and, hence, its effective final power. Moreover, the most effective barrier against the migration of lens epithelial cells and posterior capsular opacification is a capsulorhexis that overlies the edge of the optic for 360°. For these reasons, the surgeon should strive for a consistently sized, round capsulorhexis.

NUCLEAR DISASSEMBLY

Because this subject is covered extensively in the other articles in this series, only a few basic points will be emphasized here.

Thorough hydrodissection at the outset is mandatory for subsequent rotation of the nucleus. As the saying goes, "a stuck nucleus is a stuck surgeon." An effective technique is to use an irrigator with a 90º bend such as the Chang irrigator. This instrument allows the surgeon to irrigate both to the left and right, thus improving the likelihood that the fluid wave will separate most of the nucleus from the cortex and capsular bag. Beginning surgeons typically struggle due to inadequately forceful irrigation and a failure to insert the tip far enough toward the periphery to prevent backflow around the outside of the irrigator. When the ophthalmologist sees the fluid wave pass posteriorly, he or she then presses the tip of the irrigator down on the nucleus to express the posterior fluid around the lens equator, thereby further loosening the nucleus (Figure 1). Finally, the surgeon rotates the 90º tip posteriorly and engages the nucleus so that he or she can generate a rotational force and spin the nucleus.

The most basic form of ultrasonic nuclear disassembly involves making a groove and then splitting the nucleus. Success demands the observation of several principles:

• The groove must be wide enough for both the phaco needle and the irrigating sleeve so that the groove is deep enough

• Adequate depth is judged by the relative size of the phaco needle (usually three to four phaco needle diameters in depth centrally), a change in texture (the rough, feathery appearance of a hard central nucleus becomes smoother as the posterior nucleus is encountered), and brightening of the red reflex

• Both the phaco tip and the second instrument must be near the bottom of the groove to generate splitting
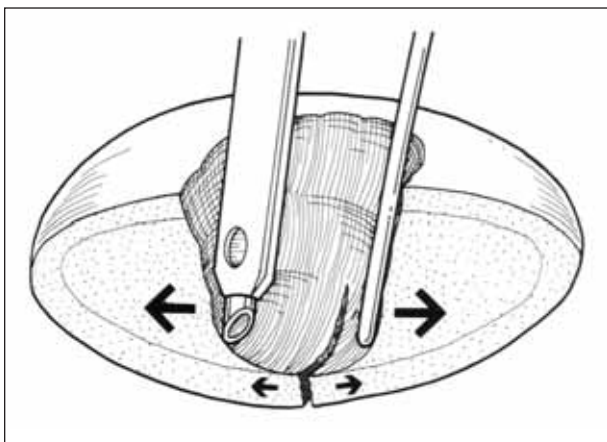

Figure 2. When splitting the nucleus, both the phaco tip and the second instrument must be deep in the groove to generate lateral forces. (Reprinted with permission from Steinert RF, ed. *Cataract Surgery*. 3rd ed. London: Saunders Elsevier; 2010.)

of the nucleus (Figure 2). If the forces are at the top of the groove, the lateral spreading motion actually presses the bottom of the nucleus together

Vacuum at the phaco tip and the second instrument are the surgeon's main tools. The phaco tip stays as close to the center as possible, while the second instrument brings nuclear pieces to it.

Even with the improved fluidics of modern phaco units, postocclusion surge can still bring the posterior capsule up to the phaco needle. Therefore, when removing the last pieces of nucleus, the surgeon must maintain the position of the second instrument between the posterior capsule and phaco tip. If the second instrument is sharp, he or she should exchange it for a spatula-shaped or other smooth instrument.

CORTICAL ASPIRATION

Thorough cortical removal is important to minimize postoperative inflammation and achieve consistent centration of the IOL. Stripping equatorial cortex from the periphery to the center is challenging in the subincisional area. Either a 45º to 90º bent tip on a coaxial I/A handpiece or a bimanual I/A system greatly facilitates total removal of the cortex. The surgeon must avoid fast maneuvers and carefully watch for wrinkles in the posterior capsule indicating that aspiration has engaged the posterior capsule.

IMPLANTATION OF THE IOL

The ophthalmologist can easily fail to notice if one haptic is out of the bag, which may result in postoperative decentration of the IOL and inflammation. Careful observation while rotating the IOL after its implantation can ensure that the lens is, in fact, fully within the capsular bag.

If sulcus fixation of the IOL is required, a single-piece acrylic lens is contraindicated. Its thick haptics can chafe the iris and cause uveitis, secondary glaucoma, and hemorrhage.

The ophthalmologist then thoroughly removes the ophthalmic viscosurgical device (OVD) used to facilitate the implantation of the IOL. A cohesive OVD is much easier to aspirate than a retentive/dispersive OVD of low molecular weight. The surgeon can safely remove an OVD that is trapped behind the optic by either placing the I/A tip under the edge of the decentered optic or pressing the I/A tip posteriorly on the center of the optic to encourage expression of the OVD around the optic for aspiration. Failure to remove the OVD will cause transient postoperative glaucoma and may result in persistent entrapment of the OVD and postoperative osmotic-driven forward displacement of the optic.

CLOSURE OF THE INCISION

Secure closure of the cataract incision is mandatory to prevent endophthalmitis. Some surgeons always place a suture in the main incision, whereas others reserve a suture for special circumstances such as persistent leakage or the presence of a glaucoma device that may lead to hypotony. Even if the main incision is securely sutured, however, the surgeon must examine any sideport incision for tight closure.

Stromal hydration is widely misunderstood as a technique to close an incision. This measure swells the stroma in order to force the stromal collagen planes together. Thereafter, the endothelial pump rapidly dehydrates the stroma, and the resultant negative intrastromal pressure holds the tissue planes in place.

POSTOPERATIVE MANAGEMENT

The surgeon's job is not complete until the eye has fully recovered. Postoperative examinations are directed toward minimizing inflammation and elevations in pressure in addition to identifying any signs of infection. For patients undergoing bilateral cataract surgery, the optical outcome in the first eye can influence the type and power of IOL selected for their second eye to maximize functional benefit. ∎

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