Described extraordinary advancements in cataract surgery techniques and technology, rupture of the posterior capsule, posterior dislocation of lens material, and the need for anterior vitrectomy still occur at a substantial rate. Roughly five anterior vitrectomy packs are sold for every 100 phaco packs (data on file with company). Part of this can be explained by elective anterior vitrectomy in pediatric cataract surgery, but the vast majority of anterior vitrectomy cases are due to capsular rupture. It is highly likely that femtosecond laser cataract surgery will further reduce the relatively low incidence of capsular rupture, but widespread adoption of this technology will take years. Capsular rupture can produce the unintended consequence of poor preparation and even hasty, unwise actions.

ANTERIOR VITRECTOMY

Anterior vitrectomy began with the pioneering work of David Kasner in the late 1960s1,2 using cellulose sponges and scissors to remove anterior vitreous. This approach was based on the concept that the crucial problem was vitreous incarceration in the cataract wound. Unfortunately, it was not recognized that severe intraoperative vitreoretinal traction is inherent in cellulose sponge anterior vitrectomy, and lifting the sponge and adherent vitreous to enable cutting and wicking caused marked vitreoretinal traction (Figure 1).

Anterior vitrectomy is not simple, as some surgeons have incorrectly stated; it is performed in close proximity to the vitreous base, a zone of permanent adherence of vitreous to the peripheral retina with 1/100 the tensile strength of the posterior retina. The majority of retinal breaks after cataract surgery occur at the posterior edge of the vitreous base. Aspirating liquid vitreous should never be done; liquid vitreous is illusory, and severe vitreoretinal traction always occurs from pulling on the collagen fiber matrix.

The use of a vitreous cutter is far safer than cellulose sponge vitrectomy. Cellulose sponges should never be used to test for vitreous during cataract surgery or penetrating keratoplasty or to remove vitreous at the site of traumatic corneoscleral lacerations. Vitreous cutters must be used with the highest possible cutting rates to minimize pulsatile vitreoretinal traction. I coined the term pulse flow to describe the volume of vitreous that goes through the cutter port with each open/close cycle. High cutting rates produce lower pulse flows, less acceleration, and therefore less force on the vitreous. They also confine energy to a region near the port, whereas lower cutting rates produce remote effects (ie, retinal breaks). The Infiniti phacoemulsification system now supports the 2,500 cuts/minute UltraVit dual-actuation cutter (both by Alcon Laboratories, Inc., Fort Worth, Texas).

The lowest effective aspiration flow rate or vacuum should be used to reduce nonpulsatile vitreoretinal traction. Technique is crucial as well; the vitreous cutter should never

Figure 1. In cellulose sponge anterior vitrectomy, lifting the sponge and adherent vitreous to enable cutting and wicking causes marked vitreoretinal traction.
be pulled back while vitreous is engaged. The safest technique is continuous engage and advance, another term I coined.

Infusion should always be used for anterior vitrectomy; dry vitrectomy inherently produces hypotony, scleral infolding often misinterpreted as choroidal effusion, miosis, and occasionally catastrophic suprachoroidal hemorrhage. The infusion should always be separated from the vitreous cutter incision; the infusion sleeve causes turbulence that reduces vitrectomy efficiency and can damage the corneal endothelium. The vitreous cutter can be placed through a sideport incision or through the pars plana, but it should never be placed through the phaco incision. A 23-gauge angulated infusion cannula is placed through another sideport. Separating the cutter from the infusion reduces turbulence, endothelial damage, and iris trauma. It is also more efficient with respect to removing vitreous.

PARS PLANA VITRECTOMY

Although many anterior segment surgeons are not comfortable performing pars plana vitrectomy, this approach removes all vitreous from the anterior segment without damaging the corneal endothelium or iris, eliminates vitreous to the wounds, and is effective for removing residual cortex. If a pars plana vitrectomy approach is utilized, the phaco wound should be sutured to prevent iris prolapse. Trocar-cannula systems have revolutionized sutureless, transconjunctival vitreoretinal surgery; however, they are unnecessary for pars plana approaches to anterior vitrectomy. The primary purpose of trocar-cannula systems is twofold: (1) to maintain misalignment of the conjunctiva that was intentionally displaced from the sclerotomy site and (2) to allow tool exchange without wound damage. Neither of these advantages is relevant to the cataract surgery setting. It is better to make a small circumferential conjunctival incision 3.5 mm posterior to the limbus and enter with a 23-gauge microvitreoretinal blade; a scleral tunnel is not recommended. Creation of a scleral tunnel in a soft eye can result in suprachoroidal introduction of the cutter.

Some manufacturers have advocated 25-gauge vitrectomy in this setting, but 23-gauge is a better choice because of tool stiffness in the context of topical anesthesia and eye movement. I use 25-gauge vitrectomy for all posterior vitrectomy cases, but these procedures are performed with a retnobulbar or occasionally peribulbar block. Visualization is essential for safe, effective anterior vitrectomy; triamcinolone particulate marking is ideal for this purpose. Triescence (Alcon Laboratories, Inc.) is preservative-free, unlike Kenalog (Bristol-Myers Squib, New York, New York).

CME AND POSTERIOR CAPSULAR RUPTURE

Many anterior segment surgeons incorrectly believe that vitrectomy causes cystoid macular edema (CME); however, total pars plana vitrectomy never causes CME, and this refutes the vitreous removal hypothesis for CME causation. Rather, CME is associated with anterior vitrectomy after posterior capsular rupture in cataract surgery not because of vitreous removal but due to iris trauma from cellulose sponges, iris retractors, and surgical manipulation. Cellulose sponges imbibe infusion fluid and liquid vitreous, swell, and traumatize the iris as they are lifted from the vitreous cavity. Additionally, direct iris trauma occurs when they are used to test for vitreous. Sweeping the wound is also a dangerous maneuver, as acute vitreoretinal traction can result. It is far safer to remove vitreous from the wound with the cutter.

When capsular rupture occurs, the first step is to inject an ophthalmic viscosurgical device (OVD) before removing the phaco probe. This will stabilize the anterior chamber and prevent lens material from moving posteriorly. An OVD barrier is ideal for prevention of vitreous mobilization into a capsular defect and the phaco wound while removing remaining lens material and implanting an IOL. Posterior dislocation of lens material never damages the retina; inappropriate action by the surgeon is the real cause of retinal damage in this situation. The phaco probe can give the illusion of anterior vitrectomy because it liquefies that hyaluronan gel, but it does not break up collagen fibers.

Using the phaco probe in vitreous in an attempt to prevent lens material from falling posteriorly is a dangerous practice. Jagged, hard nuclear fragments will never damage the retina if dropped, unless the surgeon manipulates them. Similarly, using a lens loop in the vitreous must be avoided; vitreoretinal traction is inevitable with this technique (Figure 2). Some surgeons have advocated irrigating posterior dislocated lens material in an attempt to mobilize it anteriorly—apparently unaware that forceful irrigation is used to create retinal detachment in experimental models (Figure 3). If lens material becomes dislocated into the vitreous cavity, the
A cataract surgeon should perform an anterior vitrectomy and then remove residual cortex anteriorly without producing vitreoretinal traction.

If the capsular defect is small, an IOL can be implanted in the capsular bag. If there is insufficient posterior capsule integrity to support in-the-bag implantation, sulcus implantation with an appropriate IOL is often possible. If there is insufficient capsular support for sulcus implantation, the surgeon can implant an anterior chamber lens unless the patient has Fuchs dystrophy or significant glaucoma. Many surgeons use sutured-in IOLs, but I urge surgeons to use extreme caution in these cases. There have been many cases of late weakening and breakage of sutures, endophthalmitis from erosion of the suture through a scleral flap and the conjunctiva, and suprachoroidal hemorrhage from suture passage through the pars plicata. Iris suturing can lead to uveitis, hyphema, glaucoma, and CME.

**POSTERIOR VITRECTOMY**

If posterior lens material is present, the cataract surgeon should suture the cataract wound after vitreous and cortex clean-up to prevent iris prolapse during subsequent posterior vitrectomy for removal of the lens material. Only in special circumstances should pars plana vitrectomy and removal of the posterior lens material be performed in the same procedure.

A clear cornea and well-dilated pupil are needed for optimal visualization; complicated cataract surgery does not always provide this. Endoillumination, a fundus contact lens or wide-angle viewing system, a 5,000 cuts/minute cutter, and a fragmenter are required for posterior vitrectomy and removal of lens material, in addition to requisite training and experience. Adequate visualization behind the lens equator is not possible without endoillumination and fundus visualization optics. Using the phaco probe in the vitreous cavity is unwise; it is too short and not the correct diameter for 20- to 25-gauge sclerotomy adaptors.

The fragmenter (20-gauge) has exactly the same phaco power as the phaco probe, albeit without Ozil (Alcon Laboratories, Inc.). A complete core vitrectomy should be performed before removing lens material with the fragmenter to avoid vitreoretinal traction. Triamcinolone particle marking, preferably with Triesence, facilitates more efficient and complete vitrectomy. Suction-only mode is used to lift lens material away from the retinal surface; the first arc of pedal travel controls vacuum with the Accurus or Constellation systems (both by Alcon Laboratories, Inc.). The second arc of pedal travel proportionally controls ultrasonic power. Continuous aspiration and ultrasound energy are mandatory to prevent scleral burns and plugging. Power should be stopped instantly if lens milk, indicating plugging, occurs; scleral burns will arise rapidly without fluid flow. The fragmenter must then be back-flushed outside the eye while ultrasonic power is applied. Careful examination of the retinal periphery must be done to find any retinal breaks so that endolaser retinopexy and fluid-gas exchange with sulfur hexafluoride can be performed. Liquid perfluorocarbon is unnecessary in the vast majority of cases, but it can be used to float a rock-hard, black nucleus into the anterior chamber after core vitrectomy is performed.

**CONCLUSION**

Patients have high expectations with modern cataract surgery and are not mentally prepared for a retinal detachment. It is essential to focus on the inescapable fact that many, if not most, retinal detachments after cataract surgery are driven by incorrect intraoperative management and are therefore preventable.

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