

Improving Surgical Safety With Modern Phaco Technology

Strategies With the Whitestar Signature System



BY DAVID F. CHANG, MD

We cataract surgeons and our patients continue to benefit from ongoing improvements in phaco technology. Because cataract surgery is already such a fast and efficient operation, we are primarily interested in new technologies that can expand our margin of safety—particularly in eyes with dense nuclei and weak zonules. Historically, our three main safety-related concerns with phacoemulsification have been (1) thermal damage to the incision, (2) endothelial trauma associated with prolonged ultrasound time, and (3) capsular rupture due to postocclusion surge.

Incision burns are most likely to occur with the higher power levels and prolonged ultrasound times needed for brunescient lenses. Increasing the stroke length of the vibrating phaco tip generates more frictional heat as well as more phaco power. The thicker nuclear emulsate can admix with a highly retentive ophthalmic viscosurgical device (OVD) to form a viscous plug that clogs the phaco tip or aspiration line. If fluid outflow is blocked, then the gravity-fed inflow of irrigation also ceases. With neither the inflow nor the outflow of fluid to cool it, a phaco tip in continuous mode will instantaneously burn the cataract incision.

The loss of endothelial cells is also much greater with brunescient nuclei, the size and density of which require increased phaco time and energy for emulsification compared with standard cataracts. In my opinion, it is the increased particulate turbulence occurring with brunescient nuclear fragments that causes the most damage to endothelial cells. Rigid nuclear pieces drawn by aspiration to the phaco tip do not mold and conform as well to its opening. This and the added stroke length of higher ultrasound power settings increase the chatter and turbulence of nuclear particles within the anterior chamber.

Finally, there are several reasons why posterior capsular

rupture is more common with rock-hard nuclei. The added rigidity and girth of the nucleus more directly transfers instrument-related forces to the capsule and zonules, and there is far less of an epinuclear shell to cushion the movements of the endonucleus. We typically maximize vacuum levels to improve holding power in these cases, but this increases the risk of postocclusion surge. A lax posterior capsule due to weak or deficient zonules will trampoline more easily toward the phaco tip, making even a minor or momentary degree of surge precarious.

Fortunately, all three major manufacturers provide us with bona fide advances in their latest machine platforms that address the three problems I have outlined. This article highlights specific safety features that users of the Whitestar Signature System (Advanced Medical Optics, Inc., Santa Ana, CA) should understand and deploy.

POWER MODULATIONS: WHITESTAR AND ELLIPS

This decade has brought two major advances in ultrasound technology, starting with the launch of Whitestar hyperpulse power modulation with the Sovereign system (Advanced Medical Optics, Inc.) in 2001. Shortening the pulse's duration allows us to significantly increase the frequency of ultrasound pulses. In addition, the ability to decrease the duty cycle produces a major reduction in cumulative ultrasound time. These changes significantly reduce the production of heat and the total ultrasound energy delivered by the phaco tip, and they practically eliminate the risk of wound burn. As well illustrated by the ASCRS award-winning videos of Teruyuki Miyoshi, MD, that used ultra-high-speed digital photography, alternating each ultrasonic pulse with rest periods of "off" time diminishes the repelling force of the vibrating phaco tip. This in turn reduces the chatter and turbulence of small lenticular particles at the phaco tip that would otherwise bombard the corneal endothelium.

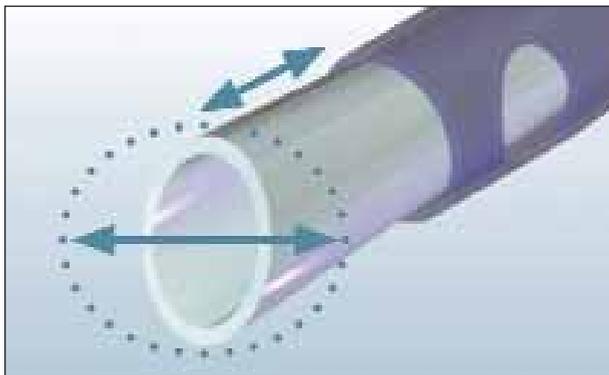


Figure 1. Illustration of the phaco tip's transverse elliptical path combined with some longitudinal axial motion.

The second major advance was the OZil Torsional handpiece (Alcon Laboratories, Inc., Fort Worth, TX), which replaces the axial movement of a traditional phaco needle with the sideways oscillation of a bent Kelman tip. Dr. Miyoshi's videos also showed that eliminating longitudinal repelling forces at the phaco tip dramatically improved followability and reduced the chatter of fragments. Advanced Medical Optics, Inc., has built on this concept by blending some longitudinal movement with a transverse elliptical path of the phaco tip (Figure 1). Ellips Transversal Ultrasound retains some longitudinal motion in order to improve the tip's ability to cut dense nuclear material. Although I have only limited personal experience with torsional phacoemulsification, Ellips seems to provide comparable benefits with a straight phaco tip, which is my strong preference for phaco chop (Figure 2). This is the single most exciting feature of the Whitestar Signature System.

I now routinely combine Ellips with variable Whitestar ICE Technology (Advanced Medical Optics, Inc.), but I use a higher, foot-pedal-controlled duty cycle that I can vary from 60% to 90%. The higher duty cycle compensates for the overall reduction in the tip's axial motion. The enhanced followability that characterizes Ellips Transversal Ultrasound is the most dramatic and obvious when used on dense nuclei. The reduced endothelial trauma in eyes with brunescient lenses is apparent in the form of clearer corneas on postoperative day 1, a well-acknowledged hallmark of phacoemulsification using nonlongitudinal ultrasound.

MICROPHACO TIP

Moving from a 19-gauge to a 20-gauge phaco tip is one strategy that all of us can use to enhance safety regardless of the brand of phaco machine. This single modification reduces the size of the incision, decreases surge, lessens the chance of accidental aspiration of the



Figure 2. The Ellips Transversal Ultrasound handpiece with a straight 20-gauge phaco tip (infusion sleeve removed).

iris or capsule, and makes it easier to pluck thin or crumbling nuclear fragments from the capsular fornices. The last advantage stems from the fact that the smaller tip becomes occluded without having to penetrate too deeply into the nucleus. The narrower lumen restricts flow, reduces surge, and prevents material from rushing in as fast as through a needle with a shaft of standard diameter. Like an I/A tip with a smaller opening, a microphaco tip provides us with greater control over which tissue is or is not aspirated. Slowing things down in this way helps when we want to guard against snagging the capsule, such as when aspirating epinucleus or thin nuclear pieces abutting the peripheral capsular bag.

Counterbalancing these advantages are several tradeoffs. A microphaco tip increases nuclear chatter because of its smaller "mouth," and its restricted flow lengthens the time needed to remove a bulky nucleus. The smaller surface area of the tip's opening also reduces the effective holding power for any given vacuum level. Fortunately, we can solve the followability problem by chopping the nucleus into smaller pieces and combining Ellips and variable Whitestar power modulations to virtually eliminate chatter. Improved pump technology enables us to safely use higher aspiration flow and vacuum to compensate for the other factors. It is therefore possible to reap the benefits of a smaller phaco tip regardless of whether we perform coaxial or biaxial phacoemulsification, and yet using a microphaco tip is the most overlooked safety modification that we surgeons can make.

ENHANCED FLUIDICS

The Whitestar Signature System's pump is a measurable improvement over that of the Sovereign. Experiments in cadaveric eyes by Randall Olson, MD, were able to measure surge associated with a variety of vacuum levels using different machines with the same experimental eye. These studies have provided quantitative confirmation of the improved chamber stability that we perceive clinically. I also strongly advocate using two optional but important safety features of the Signature's Fusion Fluidics pump: passive automatic reflux and the antisurge algorithm (discussed later).

We are much more likely to aspirate a lax posterior capsule during cortical cleanup in eyes with weak zonules. All phaco machines provide active auto reflux, whereby pressing a foot switch reverses flow in the aspiration line.

Doing so expels ensnared material, such as the posterior capsule, from the aspirating port. Passive auto reflux is a safety option of both the Signature and the Sovereign that automatically refluxes the port at every transition from foot position 2 to 1. We surgeons instinctively make this change as soon as the capsule is aspirated, and this wonderful safety feature immediately expels the capsule for us. I select this indispensable option for all cases.

ANTISURGE ALGORITHM

I believe that postocclusion surge is still the most common cause of posterior capsular rupture occurring during nuclear emulsification. The Diplomax machine (Advanced Medical Optics, Inc.) was the first to offer the occlusion mode feature, which we could program to automatically change ultrasound and fluidic parameters once the phaco tip became occluded or unoccluded. I always thought, however, that it would be much safer if we could drop the vacuum immediately before a break in occlusion. When using higher vacuum levels, this decrease would significantly reduce surge and improve chamber stability.

In response to this suggestion, the Fusion Fluidics pump technology has an antisurge algorithm to accomplish just this result. The pump's onboard computer recognizes occlusion and proactively reverses the pump to actively step down the vacuum before the break in occlusion

occurs. I use the antisurge algorithm during emulsification of chopped fragments, when breaks in occlusion are happening repeatedly. Like a car's antilock braking system, the antisurge algorithm automatically reduces the vacuum level after a predetermined interval to prevent surge as the fragments are evacuated. The algorithm tries to automate and duplicate what an experienced surgeon could do with a dual linear foot pedal once the tip became occluded. High vacuum is first used to maximize holding power, but we would then lower the vacuum with the dual linear foot pedal before delivering phaco power to clear the phaco tip.

CONCLUSION

Advances in phaco technology continue to improve our ability to manage the most challenging cataracts. Although such sophistication comes at the expense of simplicity, understanding and properly configuring our phaco technology deliver better performance while improving safety. ■

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Strategies With the Stellaris Vision Enhancement System



BY ELIZABETH A. DAVIS, MD

Enhancing safety in phacoemulsification requires optimizing fluidics and reducing the amount of ultrasound energy delivered.

Several new phaco systems represent improvements in these areas over previous platforms. This article focuses on the Stellaris Vision Enhancement System (Bausch & Lomb, Rochester, NY).

TRANSITION TO MICROINCISIONAL CATARACT SURGERY

I have been performing cataract surgery with the Stellaris Vision Enhancement System for approximately 2 years. I had been a longtime user of Bausch & Lomb's Millennium microsurgical system, with which I performed coaxial surgery through an incision of 2.8 to 3.0 mm. One of the factors motivating my switch to the Stellaris was that it has several new features that enhance surgical safety and efficiency. Additionally, the system is capable of

microincisional cataract surgery, which I was anxious to incorporate into my practice. The significance of the benefits of smaller incisions (reduced astigmatism, enhanced chamber stability, and a lower risk of leaking wounds and infection) was clear to me. Based upon many of my colleagues' experience, however, I was not enthusiastic about bimanual microincisional surgery for numerous reasons. The procedure seemed fraught with challenges in fluidics, chamber stability, and prolonged surgical time. It also demanded a significant change in technique. Although the Stellaris Vision Enhancement System may be used for biaxial surgery, the opportunity to perform microincisional surgery in a coaxial fashion was what I found particularly attractive.

I started with a standard 3.0-mm coaxial procedure but then was pleasantly surprised to experience a seamless transition to 1.8-mm coaxial surgery. I did not have to make any substantial changes to my surgical technique aside from adjusting to the use of a microincisional capsulorhexis forceps instead of a Utrata model.



(Courtesy of Uday Dengan, MD)

Figure 1. The Stellaris Vision Enhancement System’s restrictive outflow tubing.

HIGH VACUUM AND TUBING

In terms of enhancing my technique, I have found the Stellaris’ high vacuum settings (up to 600 mm Hg) beneficial. I usually employ very high vacuum for supracapsular surgery, and, even at 600 mm Hg, the chamber remains extremely stable. This technology can be combined with flow-restrictive tubing that prevents postocclusion surge at high vacuum levels (Figure 1). A mesh filter located in the tubing traps particles and prevents clogging.

A simple but ingenious new feature of the Stellaris Vision Enhancement System is the connection of the infusion tubing to the handpiece via a luer lock. This setup prevents the dangerous loss of inflow and chamber collapse that can occur if the tubing disengages from the handpiece during surgery.

FLOW MODULE

Although I prefer the vacuum module, the Stellaris Vision Enhancement System has a flow module available that can function in either a flow or vacuum mode. This feature not only allows multiple surgeons with different pumping preferences to use the same machine, but it also permits a single surgeon to toggle between flow and vacuum mode during a single case to enhance efficiency at various stages of nuclear removal. The flow module also uses an electrical pump, which eliminates the need for external compressed gases and the associated tanks.

POWER MODULATION

The Stellaris’ power modulation represents another improvement on the Millennium. Because the former delivers up to 250 pulses per second with adjustable duty cycles, the surgeon may use waveform modulations in pulse or burst modes. The ultrasound power can also be

turned on for as little as 2 milliseconds at a time. I like the Stellaris’ power modulation, because it can adapt to the type of cataract or the stage of the phaco procedure.

PHACO HANDPIECE AND FOOT PEDAL

The new titanium handpiece features six crystals versus four in most other systems. As a result, the Stellaris’ handpiece is more ergonomic and comfortable, and it has spared me a fatigued wrist at the end of a long surgical day.

As with the Millennium cataract extraction system, the Stellaris’ foot pedal is dual linear, which gives me on-the-fly control of power and either vacuum or flow. I have particularly enjoyed this feature, which allows me to alter surgical parameters instantaneously as events occur intra-operatively. Additionally, the foot pedal is now wireless, which eliminates one of the cords across the OR floor.

CONCLUSION

The Stellaris Vision Enhancement System’s enhanced fluidics, chamber stability, and power modulation improve efficiency and reduce the use of phaco energy. I encourage other surgeons to try microincisional cataract procedures on this system. They can perform bimanual or coaxial surgery and use either the vacuum or flow module. I am convinced they will not face a difficult transition but will, like me, find their surgical performance and efficiency enhanced. ■

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Strategies With the Intrepid Micro-Coaxial System



BY TERRY KIM, MD

The goals of microincisional cataract surgery are to minimize surgically induced astigmatism, hasten wound healing, and reduce the risk of a leaking wound and infection. The Intrepid Micro-Coaxial System, using both the Infiniti Vision System and the OZil Torsional handpiece (all from Alcon Laboratories, Inc., Fort Worth, TX), represents a fully integrated line of equipment and instruments specifically designed to maximize the safety and efficiency of microincisional coaxial phacoemulsification through a 2.2- or 2.4-mm incision.

OZIL TORSIONAL TECHNOLOGY

Systems that use conventional longitudinal ultrasound incorporate the forward and backward motion of the phaco tip, analogous to the movement of a jackhammer, to emulsify the lens. OZil Torsional ultrasound represents a breakthrough. The side-to-side oscillatory motion of the phaco tip is amplified to shear lenticular material, which results in more efficient emulsification by almost eliminating the repulsion caused by the cutting of nuclear tissue. As a result, the surgeon will notice less repulsion and increased followability of lenticular material, which mean a lesser dependence on the high vacuum levels needed with longitudinal ultrasound to overcome repulsion. Surgical efficiency also increases. Moreover, whereas 50% of the stroke (ie, the backward stroke) is wasted energy with longitudinal ultrasound, torsional ultrasound uses 100% of the stroke to shear nuclear material while also reducing frictional movement within the incision. As a result, torsional ultrasound achieves higher thermal safety than modulated longitudinal ultrasound.

For microincisional coaxial phacoemulsification, the Intrepid's MicroSmooth Ultra irrigation sleeve (Alcon Laboratories, Inc.) protects the wound against thermal/mechanical stress and provides sufficient flow that the bottle need not be excessively high, as with some other phaco systems.

THE INTREPID FLUID MANAGEMENT SYSTEM

The Intrepid Fluid Management System (Alcon Laboratories, Inc.) uses very low-compliance aspiration tubing to minimize the risk of postocclusion surge and to increase the stability of the anterior chamber without requiring additional irrigating flow. Stable fluidics is

essential during both routine and complex cataract surgery through a small incision, because surge and increased turbulence in the anterior chamber can heighten the risk of intraoperative complications. The Intrepid Fluid Management System allows the surgeon a sufficient range of vacuum levels during microincisional coaxial phacoemulsification with incisions as small as 2.2 mm and a bottle less than 110 cm high. The bottom line is a safer cataract procedure.

MONARCH III IOL DELIVERY SYSTEM

The Monarch III IOL delivery system with the D Cartridge (Alcon Laboratories, Inc.) completes the microincisional system by permitting the IOL's safe, controlled implantation through an unenlarged 2.2-mm incision. Compared with the C cartridge, the D cartridge has a nozzle with a 33% smaller tip and a 0.5-mm larger opening. The aspheric design and material properties of the AcrySof IOLs (Alcon Laboratories, Inc.) complement this injector; their thin optics are made of high-quality hydrophobic acrylic material, and their single-piece design facilitates in-the-bag implantation. Easier, more consistent delivery of the IOL decreases stress on the corneal incision.

PERSONAL EXPERIENCE

I have been using the Alcon Intrepid Micro-Coaxial System routinely for all of my phaco procedures for more than 2 years. The incision's proper construction and architecture are increasingly important as they grow smaller. Shorter tunnels and shallow wounds (resulting in tears at their edges) leave the incision more vulnerable to mechanical stress during phacoemulsification and I/A, and they increase the likelihood of a leaking wound that will require suturing.¹

One of the steeper learning curves in transitioning to a 2.2-mm incision occurs during the capsulorhexis. The smaller incision limits the movement of a standard capsulorhexis forceps. As a result, the surgeon must grasp the capsulorhexis' edge more frequently and torque/angulate the forceps more often to complete the tear. After a few cases, I became accustomed to these maneuvers and found the need to switch to a microcapsulorhexis forceps unnecessary.

With the 0.9-mm Mini-Flared Kelman tip with a 45° bevel (Alcon Laboratories, Inc.), I routinely use 100% torsional ultrasound with a vacuum setting of 350 mm Hg, an aspiration flow rate of 35 mL per minute, and a bottle height of



Figure 1. Using the OZil Torsional handpiece with a Malyugin ring (MicroSurgical Technology, Redmond, WA), Dr. Kim performs phaco chop on a dense nucleus.

100 cm. I particularly notice the benefits of torsional ultrasound with denser lenses: the enhanced followability and decreased anterior chamber turbulence have been impressive (Figure 1).

I have used the Monarch III IOL delivery system with the D cartridge to implant the full line of single-piece AcrySof IOLs, including the AcrySof IQ, the AcrySof Toric, and the AcrySof Restor Aspheric as well as high-powered spherical IOLs such as a 34.00 D monofocal AcrySof IOL. Regardless of the lens used, its delivery through a 2.2-mm incision has been consistently easy with a wound-assisted technique, which is my preference (Figure 2). I have found that these incisions seal completely after stromal hydration without the need for a suture, even in atypical cases such as after trabeculectomy or pars plana vitrectomy, and they are astigmatically neutral.²

LABORATORY AND CLINICAL STUDIES

A number of studies have confirmed the safety and efficiency of the Intrepid Micro-Coaxial System using the Infiniti Vision System, OZil Torsional technology, and the Intrepid Fluid Management System.³⁻⁶ My colleagues and I conducted a series of laboratory and clinical studies examining the wound's architecture and integrity after phaco procedures performed using the Intrepid system. The results of these investigations have consistently supported the positive safety profile of phacoemulsification with a 2.2-mm microincision and torsional ultrasound.^{7,8}

In an ex vivo study using human eye-banked eyes, my colleagues and I analyzed the effects of different OZil settings (ie, 100% torsional ultrasound or 70% torsional/30% longitudinal ultrasound) through a 2.8- or 2.2-mm incision. Surgical parameters—including vacuum, aspiration, and bottle-height settings—were constant for all procedures. Gross and histopathologic examination as well as findings on optical



Figure 2. Dr. Kim inserts an AcrySof Restor Aspheric lens with the Monarch III IOL delivery system with a D cartridge (A). He confirms a 2.2-mm incision size with an incision gauge at the conclusion of the case (B).

coherence tomography and scanning electron microscopy revealed no differences in the corneal wound's architecture or integrity among all groups. Compared with longitudinal ultrasound, torsional and mixed torsional/longitudinal ultrasound did not adversely affect these incisions.⁷

We recently performed a contralateral eye study in 30 human patients with bilaterally similar cataracts in order to compare the differences in various intraoperative and clinical parameters after phacoemulsification using 100% torsional ultrasound.⁸ The procedure was performed through a 2.8-mm incision in subjects' right eye (with a 0.9-mm tapered Kelman tip with a 30° bevel and the standard Infiniti Fluid Management System) and a 2.2-mm incision in their left eye (with a 0.9-mm Mini-Flared Kelman tip with a 45° bevel and the Intrepid Fluid Management System). We chose these tips to maximize the fluidic performance for the corresponding size of incision. The surgical techniques (ie, prechop, horizontal chop, etc.) and settings (ie, vacuum, aspiration, and bottle height) were similar for each patient. The parameters we studied included the accumulated usage of ultrasound

energy, the usage of balanced salt solution, the change in central corneal thickness (on postoperative day 1), and the change in endothelial cell count (at postoperative month 6). Of these, the only two that showed a statistically significant difference in favor of the 2.2-mm incision were the amount of ultrasound energy used (cumulative dissipated energy) and the change in the endothelial cell count. Based on these results, we concluded that microincisional phacoemulsification with a 2.2-mm incision, the 45° beveled Mini-Flared Kelman tip, 100% torsional ultrasound, and the Intrepid Fluid Management System is a safe and effective procedure that may offer favorable clinical and intraoperative benefits to our patients.

CONCLUSION

The Intrepid Micro-Coaxial System includes the 2.2-mm ClearCut metal keratome blades, OZil Torsional ultrasound, the Intrepid Fluid Management System, the Monarch III IOL delivery system with the D cartridge, and the line of AcrySof Aspheric IOLs. This platform offers the latest integrated technology specifically designed to enhance the safety and efficacy of modern cataract surgery. ■

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