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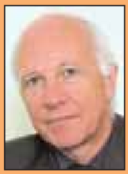
Cataract Surgery's Next Evolution

Phacoemulsification with the INTREPID Micro-Coaxial System

Cataract Surgery's Next Evolution

Surgeons exploring the frontier of cataract extraction discuss their adoption of the micro-coaxial technique, their preferred parameters and instrumentation, and their experience with the new INTREPID Micro-Coaxial System.

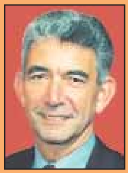


"The keys to well-executed micro-coaxial surgery are (1) knowing that you have secure wound construction, (2) obtaining a phaco system that provides stable fluidics with limited irrigation flow, and (3) adopting an IOL with a long, successful track record that can be implanted through a small incision."

—David Allen, BSc, FRCS, FRCOphth, United Kingdom

"Small corneal incisions are attractive to cataract surgeons because they have been shown to induce less astigmatism and self-seal more easily, thus potentially reducing the risk of wound leakage and endophthalmitis."

—Terry Kim, MD, United States



"Phaco fluidics have also evolved to suit micro-coaxial surgery. The INFINITI Vision System features a new cassette called the INTREPID Fluidic Management System (FMS), which has low-compliance tubing that almost eliminates postocclusion surge. In my experience with the INTREPID FMS, the chamber's depth remains rock-solid during the entire procedure."

—Samuel Masket, MD, United States

"The innovative MONARCH III D cartridge used in combination with the MONARCH III injector will make the transition to a micro-coaxial technique much easier and enables the injection of a full 6.0-mm optic, single-piece, hydrophobic acrylic aspheric IOL through an unenlarged micro-incision."

—Khiun F. Tjia, MD, The Netherlands

Included with this supplement is a CD (back cover) that contains surgical footage and detailed discussions of important applications of micro-coaxial phacoemulsification. Surgeons describe, use, and demonstrate micro-coaxial and torsional technologies so you may better visualize the exciting potential and benefits of these unique lens-removal modalities.

Cataract Surgery Evolves

New IOL implantation and fluidics technologies make transitioning to a micro-coaxial technique easier and safer.

BY DAVID ALLEN, BSc, FRCS, FRCOphth

The keys to well-executed micro-coaxial surgery are (1) knowing that you have secure wound construction, (2) obtaining a phaco system that provides stable fluidics with limited irrigation flow, and (3) adopting an IOL with a long, successful track record that can be implanted through a small incision. Here, I discuss my transition to 2.2-mm micro-coaxial phacoemulsification. I will share how the INFINITI Vision System with the new INTREPID Fluidic Management System (FMS) (Alcon Laboratories, Inc., Fort Worth, TX) maximizes the safety of this technique and describe the ease of inserting the Aspheric AcrySof IOL with the new MONARCH III D cartridge (Alcon Laboratories, Inc.).

INCISIONAL TECHNIQUE

Some time before I transitioned to micro-coaxial phacoemulsification, I performed a three-plane incision. I made an initial partial-thickness groove in the cornea at the incision site, passed the blade through the stroma beginning in the bed of that groove, and then made a conscious entry into the anterior chamber. Like many other surgeons, I was taught that the initial groove helped the incision to seal postoperatively. In practice, I found that this step was rather inconsequential. I therefore changed to making what is termed a *single-plane* incision, although this is a misnomer. When constructing this incision, the surgeon must angle the blade correctly and make a curving movement to achieve the full 2-mm length within the stroma before entering the anterior chamber. When I transitioned to a 2.2-mm incision, I maintained this single-plane technique.

Specifically, I begin the micro-coaxial technique by making a very small sideport incision at the limbus, 2 clock hours away from where my main incision will be. I follow this with a careful 2.2-mm incision as described above using a disposable 2.2 INTREPID HP^2 metal blade (Alcon Laboratories, Inc.) starting just at the edge of the vascular zone of the cornea.

I use the mark on the blade as a guide for the incision's length. I pass the blade through the stroma until I reach the mark, and then I enter the anterior chamber. This approach produces a suitably square incision that will self-seal and thereby help to reduce the possibility of postoperative endophthalmitis (Figure 1). Next, I fill the anterior chamber with viscoelastic and prepare to make the capsulorhexis with standard Corydon forceps (Moria; Antony, France). When I perform a capsulorhexis through a 2.2-mm incision, my movements are only slightly more restricted than when performing this maneuver through a 2.8-mm incision, but not to the point that I have to alter my surgical technique. Because my usual technique for creating the capsulorhexis is to grasp the capsule four or five times, it was not difficult for me to perform this step through a 2.2-mm incision. Surgeons who like to grasp the capsule only once or twice when making a capsulorhexis may initially need to repeat this action more often when they transition to a smaller incision.

CATARACT EXTRACTION

I recommend that surgeons have more than one cataract extraction technique in their repertoire to

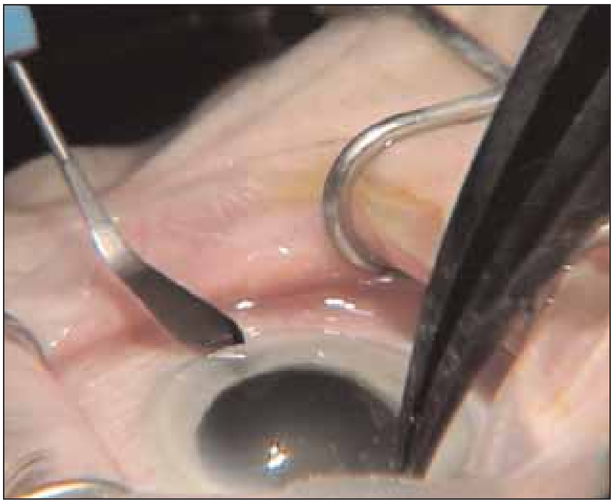


Figure 1. Successful micro-coaxial cataract surgery begins with an appropriately constructed 2.2-mm incision. Smaller "square" corneal incisions have been shown to induce less astigmatism and self-seal more easily.

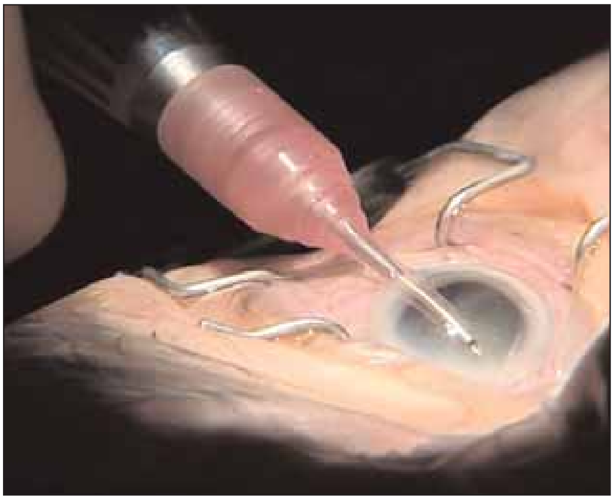


Figure 2. The 0.9-mm Mini-Flared ABS Kelman tip utilizes a new flared design to help enhance torsional performance. Its microbore shaft enhances irrigation and suppresses surge.

accommodate differences between soft and hard cataracts. For soft-to-moderately dense lenses, I use my standard chop technique with a 45° beveled Mini-Flared Kelman phaco tip and the Ultra Sleeve (Alcon Laboratories, Inc.) (Figure 2), because its 20° downward bend sculpts the nucleus deeply. I initially sculpt the superficial cortex and epinucleus centrally until I can see the surface of the nucleus itself. In this way, I can clearly see the junction between cortex/epinucleus and endonucleus, and so I ensure that the chopper is passed safely out to the equator of the nucleus in this plane. I begin to dissect the nucleus by impaling it with short bursts of torsional ultrasound before passing the chopper out to the equator. I then bring the nucleus horizontally toward the phaco tip to achieve a split. Next, I chop each half of the nucleus into two or four pieces. Each nuclear fragment is then attracted via the fluidic stream to the OZil Torsional handpiece (Alcon Laboratories, Inc.), which emulsifies it very efficiently.

With traditional longitudinal phacoemulsification, surgeons grew used to grasping a nuclear fragment and waiting for vacuum to build before applying phaco power. With torsional ultrasound and its inherent lack of repulsion, however, we can apply power long before vacuum has built up. The system is very efficient, because it can shear the lens material as it is being acquired at the phaco tip.

To remove very dense cataracts, I use a variation of the chop technique I learned from Abhay Vasavada, MS, FRCS, of Ahmedabad, India, who has a lot of experience with these lenses using both traditional and now torsional phacoemulsification. Again, the combination of the OZil handpiece and the angled Kelman tip makes it easy to sculpt a small but deep crater into the center of the nucleus without any effort on the surgeon's part or any distortion of the cornea. The remaining ring of dense nucleus is then chopped horizontally, and the central crater allows the surgeon to ensure that the pieces split completely. With very dense cataracts, the posterior nuclear plate is often very difficult to crack using the standard chop technique.

Although the OZil handpiece allows users to alternate between traditional and torsional ultrasound power, I favor using continuous torsional power for almost every case. Because the torsional movement creates less frictional heat than traditional ultrasound's movement (its thermal potential is less than one third of that of longitudinal phacoemulsification for similar power and modulation), torsional ultrasound can be used safely with continuous power settings in smaller incisions, thus minimizing the risk of damaging the cornea.

FLUIDICS

One of the challenges of reducing incisional size in phacoemulsification is maintaining adequate inflow to support the use of high vacuum levels. If the maximum potential inflow of fluid into the eye through the infusion sleeve does not exceed the amount of fluid leaving the eye at all times, the anterior chamber will shallow or collapse. Surgeons who use traditional phacoemulsification are accustomed to using higher vacuum and flow settings to counteract the repulsive forces of longitudinal

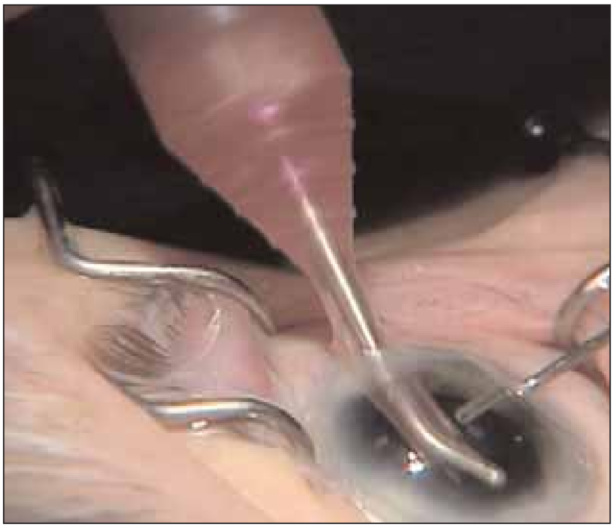


Figure 3. Designed specifically for micro-coaxial procedures, the new INTREPID I/A Tip enhances irrigation. The MicroSmooth Ultra Sleeve minimizes wound leakage and reduces stress on the ocular tissues.

Figure 4. The new MONARCH III IOL Delivery System with the D cartridge has an opening that is 0.5 mm wider than the C cartridge's opening to allow easier loading of a full-optic AcrySof IQ Aspheric IOL.

ultrasound and hold nuclear material on the phaco tip. When they move to micro-incisions, high-vacuum/high-flow surgeons using traditional phacoemulsification will need to reduce these fluidic settings to compensate for less irrigation through these smaller incisions, and reducing their settings will in turn hurt their surgical efficiency.

With OZil Torsional phacoemulsification, however, this reduction in fluidics does not compromise efficiency. I employ the same parameters for 2.2-mm incisions that I did for 2.8-mm incisions when I use the Mini-Flared ABS tip. Surgeons who want to continue employing higher flow and vacuum settings can use the new enhanced INTREPID FMS, another key product in the INTREPID Micro-Coaxial System. This FMS was designed especially for micro-coaxial phacoemulsification and has more rigid aspiration tubing that significantly reduces postocclusion surge, even with vacuum levels of up to 500 mm Hg with the Mini-Flared Kelman tip in a 2.2-mm incision.

The balance between inflow and outflow is just as important with I/A as it is with phacoemulsification for reducing the potential for postocclusion surge and capsular rupture in intraocular surgery. The new INTREPID I/A Tip (Figure 3) was also designed specifically for the micro-coaxial phaco procedure. The shaft diameter of this tip has been reduced so that there is a maximal inflow of fluid between the tip and the Ultra Sleeve. This design allows a greater inflow of balanced salt solution in order to minimize the chance of postocclusion surge.

NEW SMALLER INSERTION CARTRIDGE

For the past year, surgeons who have been performing 2.2-mm micro-coaxial phacoemulsification have used the MONARCH C cartridge (Alcon Laboratories, Inc.) to deliver the IOL into the anterior chamber. The design of the C cartridge required the surgeon to insert just its top bevel into the anterior lip of the corneal incision and apply considerable pressure to the eye to hold the cartridge in place while introducing the lens through the incision. Although the MONARCH III IOL Delivery System (Alcon Laboratories, Inc.) is not yet widely available, my staff and I had the opportunity to try it during its devolvement, and we believe the new D cartridge with the MONARCH III handpiece (Figure 4) will facilitate IOL delivery through the 2.2-mm incision for all surgeons. The D cartridge has a reduced-profile nozzle that eliminates the need to apply pressure to the eye during the IOL's delivery. The technique with the D cartridge is to engage the entire nozzle tip of the cartridge into the lip of the incision while maintaining much gentler pressure on the incision and inserting the IOL into the anterior chamber. The D cartridge was developed for injecting the single-piece AcrySof Aspheric IOLs (Alcon Laboratories, Inc.). The IQ SN60WF lens is validated for up to 27.00 D. Validation of other single-piece models will follow.

FINAL THOUGHTS

Surgeons who use a piecemeal approach to micro-coaxial cataract surgery have to ensure that the particular tip and sleeve combination will work well with the fluidics performance of their phaco machine. The IOL may not have a cartridge suitable for use with these small incisions. The different parts of the INTREPID Micro-Coaxial System were developed to work in collaboration. The INTREPID series blades, INFINITI combined with the new enhanced FMS and OZil Torsional handpiece, the Ultra Sleeve, the Mini-Flared tip, the aspheric AcrySof IOL design, and finally the MONARCH III IOL injector with the D cartridge have been specifically developed to create a comprehensive micro-coaxial phaco system in which all components work together in harmony.

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The Case for Micro-Coaxial

Current research supports the trend toward smaller surgical incisions.

BY TERRY KIM, MD

The latest trend in cataract surgery is smaller corneal incisions. Today, most surgeons operate with incision sizes of 2.75 to 3.00 mm and achieve very good results. Over the last few years, some surgeons have progressed to using micro-incisions with various surgical techniques and have generated a lot of interest. Overall, smaller incisions are delivering surgical benefits, particularly when used in conjunction with advances in phaco technology. The following discusses the latest research on these smaller incisions, torsional phaco technology, and new lens delivery systems, and also provides pearls for achieving the best outcomes using micro-coaxial phacoemulsification.

MICRO-INCISIONS: BENEFITS AND LIMITATIONS

Small corneal incisions are attractive to cataract surgeons because they have been shown to induce less astigmatism and self-seal more easily, thus potentially reducing the risk of wound leakage and endophthalmitis.[1] However, some studies have indicated that micro-incisions may reach a point of diminishing returns, at least with longitudinal phaco technology and a bimanual approach.[2] Incisions that are too small (1.1 to 1.2 mm) can limit the surgeon's ability to maneuver surgical instruments and therefore are prone to intraoperative distortion and mechanical trauma. Nor do these incisions afford enough room to sleeve the instruments. Operating with unsleeved instruments poses two potential problems: transmitting heat from the instrument to the wound; and limiting the movement of the instruments due to the tightness of the incisions, a phenomenon called *oarlocking*. The combination of mechanical stress from the friction of the instrument and the thermal stress of having no sleeve further increases the risk of trauma to micro-incisions, especially in difficult cases that require more phaco energy (ie, dense lenses).

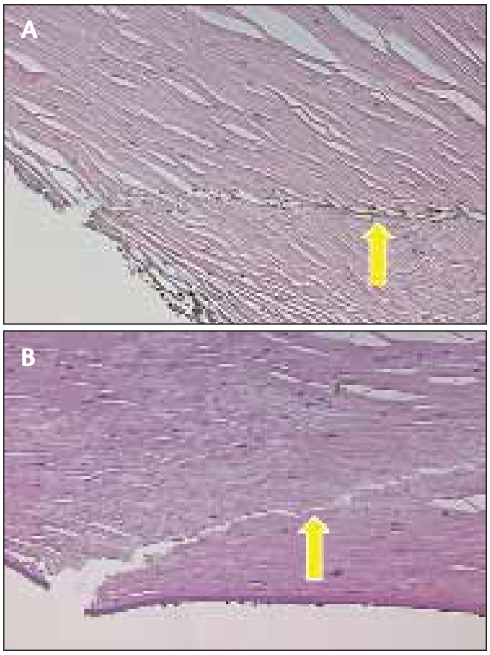

Figure 1. Histopathologic examination reveals evidence of India ink particles along the wound tract of the bimanual 1.2-mm incision (A, arrow) but not in the wound tract of the micro-coaxial 2.2-mm incision (B, arrow).

Anecdotally, some surgeons using the bimanual technique have had to suture their micro-incisions. Some are even making a third incision to use for IOL insertion because the distorted bimanual micro-incisions lack integrity. This result defeats the purpose of small-incision surgery, because adding a third incision of approximately 2.75 mm to a cornea with two 1.2-mm incisions brings the total size of the corneal wounds to more than 5 mm.

MICRO-COAXIAL AND TORSIONAL

Due to the technical limitations of the micro-incisional bimanual technique, practitioners have been looking for an alternative method of performing phacoemulsification through smaller incisions that capitalizes on the benefits and minimizes the drawbacks. We evaluated the INTREPID Micro-Coaxial System using the INFINITI Vision System, the OZil Torsional handpiece, and single-piece AcrySof Aspheric IOLs (all manufactured by Alcon Laboratories, Inc., Fort Worth, TX) as the foundation. Included in the evaluation

Figure 2. Scanning electron microscopic examination demonstrates qualitatively greater endothelial cell loss and damage to Descemet's membrane in the bimanual 1.20-mm incision (A) compared to the micro-coaxial 2.20-mm (B) or standard coaxial 2.75-mm (C) incisions.

was the new advanced INTREPID Fluidic Management System (FMS). Each component of this micro-coaxial system adds particular benefits to optimize micro-incisional cataract surgery. The OZil Torsional ultrasound handpiece amplifies the side-to-side oscillatory motion to the phaco tip (vs the longitudinal forward and backward motion of conventional ultrasound), minimizing stress to these smaller 2.2- to 2.4-mm incisions. This motion has resulted in more efficient emulsification (as 100% of the stroke is utilized) with less repulsion and increased followability of nuclear material. In addition, the micro-coaxial Ultra Sleeve (Alcon Laboratories, Inc.) protects the smaller incision against thermal/mechanical stress and provides sufficient irrigation flow. The advanced INTREPID FMS uses low-compliance tubing, which minimizes fluidic fluctuations intraocularly to increase the stability of the anterior chamber. Stable fluidics is especially beneficial when operating through a small incision because of the limited irrigation flow of smaller sleeves.

Furthermore, the new FMS allows surgeons to transition to micro-coaxial cataract surgery without compromising phaco settings. When I began using micro-coaxial phacoemulsification with longitudinal ultrasound, I had to decrease my vacuum and aspiration settings by 20% to avoid postocclusion surge and maintain anterior chamber stability. Now, with the combination of OZil and the INTREPID FMS, I have been able to return to my previous high-vacuum, high-flow phaco settings for prechop and phaco chop techniques (see *Pearls for Success With 2.2-mm Incisions*).

LABORATORY AND CLINICAL RESEARCH

All of these advances offered by the INFINITI Vision System translate into better outcomes as evidenced by laboratory and clinical studies.[3-5] In an ex vivo study, my co-investigators and I divided 15 cadaveric human eyes into three surgical groups undergoing simulated longitudinal phacoemulsification with standard ultrasound settings. One group received 2.8-mm coaxial incisions, the second 2.2-mm coaxial micro-incisions, and the third received 1.2-mm bimanual micro-incisions.[3]

We evaluated the architecture and integrity of the differently sized wounds in each surgical group with gross, histopathologic, and scanning electron microscopic examination to assess wound leakage, penetration of India ink into the wound and the anterior chamber, and ultrastructural damage to the cornea. Spontaneous wound leakage occurred in all of the eyes that underwent bimanual phacoemulsification, most likely due to a phenomenon known as *incisional molding*, where mechanical and thermal stresses on the wound cause the cornea to gape and fail to seal. Wound leakage occurred in all eyes in the bimanual group, in only one eye in the standard coaxial phacoemulsification group, and in no eyes that underwent micro-coaxial phacoemulsification. Of the eyes that underwent histopathologic examination, India ink staining penetrated into the wound in one eye that underwent standard coaxial phacoemulsification and in no eyes in the micro-coaxial group; however, it did enter the wound and anterior chamber in two eyes that received bimanual micro-incisional phacoemulsification (Figure 1). Qualitatively (this was not a quantitative study), scanning electron microscopy demonstrated more trauma to Descemet's membrane and the endothelium with the bimanual micro-incisional technique than with the micro-incisional and standard coaxial techniques (Figure 2).

My colleagues and I conducted a follow-up ex vivo study to examine the effects of different OZil settings and wound sizes on postoperative wound architecture.[4] We tested simulated phacoemulsification with 100% fixed OZil ultrasound and 70% OZil/30% longitudinal (mixed) ultrasound settings in four treatment groups using 2.8- and 2.2-mm incisions. We analyzed these wounds with gross, histopathologic, and

Figure 3. The study used the 0.9-mm 45º Mini-Flared tip and concluded that 2.2-mm micro-coaxial phacoemulsification with 100% OZil Torsional ultrasound is as safe and effective as the standard coaxial technique.

PEARLS FOR SUCCESS WITH 2.2-MM INCISIONS

WOUND CONSTRUCTION

Successful micro-coaxial cataract surgery starts with a properly constructed 2.2-mm incision. After blade inspection and globe fixation (with a fixation ring, cotton-tipped applicator, 0.12 forceps, etc.), I adjust my OR microscope to ensure an amply magnified and focused view of the temporal cornea. I avoid the conjunctiva and enter the peripheral cornea at an obtuse angle with the 2.2-mm blade to mid-stromal depth. I then flatten the angle of my blade and follow the curvature of the cornea while I slowly advance the blade centrally at the same depth. Proceeding at too flat an angle will result in a shallow incision that can easily tear at the edges with minimal stress ("dog-earring of the incision"). Proceeding at too steep an angle will result in a premature entry into the anterior chamber with an incision that may not self-seal. Once the 2-mm etching on the blade reaches the external aspect of the incision, I lift the heel of the blade so that the tip can enter the anterior chamber, resulting in a square incision (this construction has been shown by Paul Ernest, MD, and colleagues to resist deformation and improve wound stability[1]). I avoid longer tunnels with 2.2-mm incisions, as this can significantly restrict the movement of the capsulorhexis forceps and also interfere with the view of the lens during phacoemulsification.

THE CAPSULORHEXIS

One of the more noticeable adjustments in surgical technique with 2.2-mm incisions takes place during the creation of the capsulorhexis. Limited movement of a standard capsulorhexis forceps in this smaller incision may require more frequent grasping of the capsulorhexis' edge and more manipulation of the forceps to grasp the edge. The subincisional view of the capsulorhexis also becomes more limited due to the more anterior location of the internal aspect of the incision. If necessary, a specially designed capsulorhexis forceps (ie., Mackool-Inamura Micro-Coaxial Capsulorhexis Forceps; Duckworth & Kent Ltd., Baldock, Hertfordshire, England) can be used to facilitate the capsulorhexis with these micro-incisions.

INSTRUMENTATION

When transitioning to the micro-coaxial phaco technique, I recommend starting with a 2.4-mm incision and a 0.9-mm Mini-Flared Kelman tip (with OZil Torsional ultrasound). Once you become accustomed to the feel of the blade and the angulation on this tip, you can move to a 2.2-mm incision using a 0.9-mm Mini-Flared Kelman tip with a 45° bevel (with OZil Torsional ultrasound). The angulation of the phaco needle (and perhaps the steeper bevel tip) allows for greater amplification of the side-to-side oscillation of the phaco tip during torsional ultrasound, resulting in more efficient phacoemulsification.

Regarding the INTREPID FMS, be aware that its low-compliance tubing will be less flexible than you are used to. You may not notice this decreased flexibility during phacoemulsification, but you probably will notice it during I/A, during which the I/A tip is typically moved more actively in different directions and angles during cortical removal. In the beginning, start with routine cases and decrease your vacuum and aspiration flow settings by at least 20% until you become comfortable with the fluidics in the anterior chamber. This transition is typically quick, and you should soon be able to return to your normal settings. With very dense lenses, you may want to use mixed ultrasound—a combination of, for instance, 80% torsional ultrasound with 20% traditional ultrasound—in case you encounter some micro-occlusions. Adding burst mode to the OZil may also help prevent micro-occlusions with these types of lenses.

PERSONAL SETTINGS

My conventional settings for 2.2-mm micro-coaxial phacoemulsification for a dense nuclear sclerotic cataract that I plan to phaco chop include 100% torsional ultrasound with a 0.9-mm Mini-Flared Kelman tip with a 45° bevel, a vacuum setting of 350 mm Hg with an aspiration flow rate of 35 mL per minute, and a bottle height of 100 cm. If I encounter micro-occlusions with a very hard lens, I typically decrease the torsional ultrasound to 80% and add 20% of traditional ultrasound. This combination of ultrasound has eliminated the occurrence of these mini-occlusions.

1. Ernest PH, Lavery KT, Kiessling LA. Relative strength of sclera and clear corneal incisions constructed in cadaver eyes. *J Cataract Refract Surg.* 1994;20:6:626-629.

Figure 4. The new MONARCH III D cartridge and handpiece will facilitate micro-coaxial IOL delivery. The D cartridge's enlarged loading area and reduced-profile nozzle were developed for injecting single-piece AcrySof Aspheric IOLs.

scanning electron microscopic examination as described earlier and found no noticeable differences in corneal wound architecture or integrity among the four treatment groups. We also examined these wounds with the Visante anterior segment OCT (optical coherence tomography) unit (Carl Zeiss Meditec, Inc., Dublin, CA) and found the results to correlate with our gross and microscopic findings. We concluded that torsional and mixed ultrasound settings did not appear to induce any additional adverse effects on the integrity or architecture of both 2.8-mm and 2.2-mm corneal incisions when compared with our longitudinal phacoemulsification results. Our findings also show that commercially available anterior segment OCT may be a clinically useful tool for assessing the integrity of corneal wounds postoperatively.

At the ASCRS annual meeting in April 2007, we presented the results of a clinical study comparing various intraoperative and clinical parameters during torsional phacoemulsification. We used the OZil Torsional handpiece through a 2.8-mm incision (right eyes) versus a 2.2-mm incision (left eyes) in 30 patients with bilaterally similar cataracts.[5] My co-investigators and I used a slightly different tip in the patients' right eyes (the 0.9-mm tapered Kelman tip with a 30° bevel [Alcon Laboratories, Inc.]) versus the left eyes (the 0.9-mm Mini-Flared Kelman tip with a 45° bevel [Alcon Laboratories, Inc.]) (Figure 3). We believed the steeper angulation of the beveled tip should better emulsify material with the side-to-side movement generated by torsional ultrasound.

We selected these tips to optimize the fluidic balance for the corresponding incision sizes. We used a Micro Sleeve with INFINITI's traditional FMS for the 2.8-mm incisions and an Ultra Sleeve with the new INTREPID FMS for the 2.2-mm incisions. Both sets of eyes received continuous torsional ultrasound with identical settings. Measurement parameters included accumulated energy used, changes in central corneal thickness, the amount of balanced salt solution used, and the number of times we had to hydrate or suture an incision.

The only parameter to show statistical significance between the two groups was the amount of energy we used, which we measured as cumulative dissipated energy (CDE). CDE was higher for the right eyes (standard coaxial 2.8-mm incisional phacoemulsification) versus the left eyes (2.2-mm micro-coaxial phacoemulsification). We therefore concluded that 2.2-mm micro-coaxial phacoemulsification with continuous torsional ultrasound is as safe and effective as the standard coaxial technique, and perhaps even more so because it uses less energy.

IOL TECHNOLOGIES

Finally, the MONARCH III IOL delivery system with the new D cartridge (Alcon Laboratories, Inc.) (Figure 4) has enabled easier and safer implantation of the AcrySof single-piece Aspheric lens platforms through micro-incisions. Compared to the C cartridge, the diameter of the D cartridge's opening has increased from 5.5 mm to 6.0 mm (allowing for easier IOL loading with virtually no resistance), and the nozzle tip is 33% smaller (resulting in less stress on the corneal incision). Consequently, I have witnessed better sealing of my wounds with a reduced need for stromal hydration and suture placement.

The combination of these technologies—the INTREPID series blades, OZil with the INTREPID FMS, and AcrySof Aspheric IOLs (eg, the SN60WF)—has resulted in a fully integrated system of micro-coaxial instrumentation that requires minimal transition in the surgical techniques, instruments, and flow settings used by surgeons today. Thanks to these advancements, we now have a new standard in cataract surgery that will allow surgeons to operate with more safety, efficiency, and accuracy, with the ultimate goal of improving patient outcomes.

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Micro-Incisions: Advantages and New Instrumentation

Why the INFINITI Vision System is the best platform for micro-coaxial phacoemulsification.

BY SAMUEL MASKET, MD

I believe that wound configuration, wound management, and the establishment of physiologic IOP at the close of surgery make the difference in preventing postoperative endophthalmitis. Over the last few years, there has been growing concern in ophthalmology about higher rates of postoperative infection associated with clear corneal incisions.[1] Because the correlation is not universal, I believe the reason for this incidence relates to wound construction—that there is a greater risk of infection in incisions that are not made in a square or nearly square configuration or are distorted or stretched during surgery.

SUPPORTIVE RESEARCH

Original work by Paul Ernest, MD, and colleagues[2] established that incisions with a square surface architecture are considerably more resistant to deformation after surgery should a patient rub or squeeze his eye firmly. An unstable incision would allow the anterior chamber to leak, thus making the eye soft (creating a gradient of pressure from the outside in). This in turn would allow material from the tears and the surface of the eye to enter the anterior chamber. Presumably, bacteria enter with this ingress of fluid and increase the rate of infection.

ADVANTAGES OF SMALL INCISIONS

Evidence is mounting that micro-incisions—2.4 mm or smaller—are superior to larger wounds in terms of stability and their resistance to deformation by patients' rubbing and blinking. The reason may be that ergonomically, it is easier to create a 2-mm than a 3-mm-long square incision.

Recently, colleagues and I conducted a study of 2.2-mm corneal micro-incisions with square surface architecture in 50 cataract surgical eyes in the early postoperative period.[3] At the close of surgery, we established IOP at physiologic levels and performed an intraoperative

TABLE 1. SURGICALLY INDUCED ASTIGMATISM REDUCED IN MICRO-INCISIONAL SURGERY

Incision Size	2.2 mm (n=32)	3.0 mm (n=16)	*P* Value
Surgically Induced Astigmatism	**0.11 D**	**0.33 D**	**.001**
Range	0 to 0.375 D	0 to 0.75 D	
Axis	**13.4°**	**21.1°**	**.03**
Shift	(2° to 37°)	(2° to 60°)	

Data from Masket S. Surgically induced astigmatism with 2.2 mm clear corneal cataract incisions. Paper presented at: The 2006 ASCRS/ASOA Symposium & Congress; March 18, 2006; San Francisco, CA.

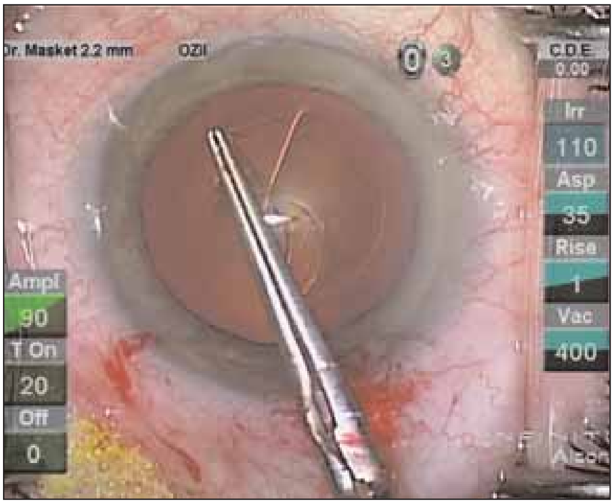

Figure 1. A capsulorhexis using standard forceps is only slightly more constrained through a 2.2-mm micro-incision.

Seidel test to ensure there was no leakage. No eye required any sutures. We measured the eyes at 2 and 6 hours after surgery, and we did not find one hypotonous eye. All the IOPs were physiologically normal, and there was no sign of wound instability.

Another advantage of using micro-incisions is a lessened chance of surgically induced astigmatism. Wider incisions have greater keratometric flattening in their meridians.

To measure the effect of micro-incisions on astigmatism, my colleagues and I studied 22 patients who required cataract surgery in both eyes. Each patient was randomized to receive a 2.2-mm micro-incision in one eye and a 3.0-mm incision in their fellow eye. We found a clinically and statistically significant reduction of surgically induced astigmatism in the 2.2-mm group compared with the 3.0-mm group[4] (Table 1).

CLINICAL USE OF MICRO-INCISIONS

Based on the results of my research as well as my personal experience, I now use micro-coaxial phacoemulsification in every cataract surgery, whether routine or complex. I believe that these incisions make it easier for the surgeon to work intraoperatively and also provide stability postoperatively, so long as he does not distort the corneal tissue.

To make the incision, I use a diamond blade that cuts to 2.2 mm with dull sides, as well as the new INTREPID HP^2 steel blades from Alcon that were designed to create a perfect 2.2-mm incision. Also, I recently obtained a diamond blade designed by Doug Mastel, MD, for 2.2-mm surgery that I think is exquisite.

For surgeons who wish to transition to using 2.2-mm micro-incisions from 3.0-mm incisions, the learning curve is almost nil. Despite a few differences between the two techniques, cataract surgical instrumentation and phaco fluidics have improved to the point that surgeons can make the transition to this technique easily (Figure 1).

To make micro-coaxial phacoemulsification safer, Alcon Laboratories, Inc. (Fort Worth, TX), has designed an Ultra Sleeve to encase phaco tips and irrigation instruments for incisions of 2.2 to 2.4 mm. The Ultra Sleeve is slightly smaller in its dimension than the Micro Sleeve (Alcon Laboratories, Inc.), which is the standard sleeve used for 2.75- to 3.25-mm incisions. I raised the irrigation bottle to an infusion height of 110 cm with the Ultra Sleeve compared with the 78 cm used with the Micro Sleeve in traditional 3-mm surgery.

Phaco fluidics have also evolved to suit micro-coaxial surgery. The INFINITI Vision System (Alcon Laboratories, Inc.) features a new cassette called the INTREPID Fluidic Management System (FMS), which has low-compliance tubing that almost eliminates postocclusion surge. In my experience with the INTREPID FMS, the chamber's depth remains rock-solid during the entire procedure. Additionally, I combine a coaxial micro-incisional technique with the OZil Torsional handpiece available on the INFINITI system. The match works beautifully. I have been using a 0.9-mm Reversed Mini-Flared Kelman phaco tip (Alcon Laboratories, Inc.; not yet available), which fits perfectly through the 2.2-mm incision and enables me to remove cataracts of all densities with 100% torsional phacoemulsification (Figure 2). The main advantages of torsional ultrasound are that it uses less energy and it greatly reduces repulsive forces at

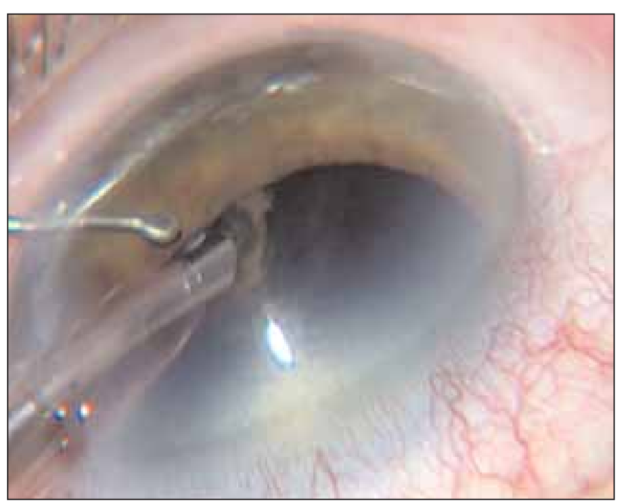

Figure 2. The Reversed Mini-Flared Kelman Tip offers a bevel-down design for easier nuclear purchase. Torsional ultrasound creates less frictional heat than traditional ultrasound and minimizes the risk of damaging the cornea in smaller incisions.

the phaco tip. As a result, surgeons do not need to use aggressive aspiration flow rates and vacuum settings and can therefore perform safer surgery. I use a flow rate of 35 mm Hg and a vacuum of 400 mm Hg with pure burst torsional phacoemulsification with a variable amplitude of up to 90%.

LENS TECHNOLOGY

IOL technology has also evolved to accommodate micro-coaxial surgery. The AcrySof IQ SN60WF lens (Alcon Laboratories, Inc.) is a full-sized, 6-mm aspheric IOL that I can easily implant through a 2.2-mm incision using the new MONARCH III D cartridge (Alcon Laboratories, Inc.). The IQ lens is my micro-coaxial IOL of choice for the majority of my patients.

The D cartridge has approximately 33% less cross-sectional area at the nozzle's tip compared with the MONARCH II C cartridge, and it allows me to implant the IQ SN60WF lens through a 2.2-mm incision. My staff and I like that the D cartridge loads more easily than the C cartridge, thanks to a slightly wider entry end. This easier loading may improve efficiency in the OR and could reduce the potential for mechanical damage to the IQ lens compared with the C cartridge.

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Efficient Micro-Torsional Phacoemulsification With Lower Fluidic Settings

Torsional ultrasound is altering how surgeons approach complicated surgery by delivering high efficiency with low fluidics settings.

BY KHIUN F. TJIA, MD

I find it exciting to watch and take part in the continual evolution in cataract surgical technology and techniques. I currently perform 2.2-mm micro-coaxial torsional phacoemulsification with the INFINITI Vision System, utilizing the new INTREPID Micro-Coaxial Fluidic Management System (FMS) (both manufactured by Alcon Laboratories, Inc., Fort Worth, TX). My micro-coaxial surgical procedure includes a 2.2 INTREPID HP^2 knife, the OZil Torsional handpiece, a Mini-Flared 45° ABS Kelman phaco tip with a 0.9-mm Ultra Sleeve, the new INTREPID FMS, and the MONARCH III handpiece and D cartridge (all manufactured by Alcon Laboratories, Inc.). All of these micro-coaxial components work together to enable what I consider to be the safest and most efficient surgical strategy for cataract extraction to date.

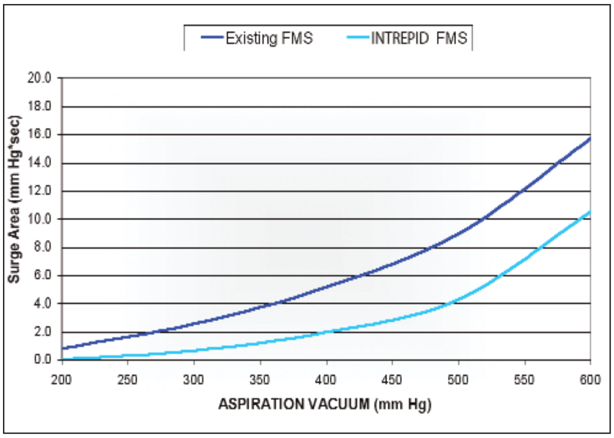

Figure 1. The new INTREPID FMS reduces postocclusion surge by approximately 50% versus the existing INFINITI FMS and provides an improved surgical response, even with low-to-moderate fluidics settings.

TORSIONAL ULTRASOUND

Increased Efficiency, Lower Fluidics

Traditional longitudinal ultrasound requires surgeons to use high aspiration flow and vacuum settings to overcome the repulsive effect of the phaco tip's forward strokes. Torsional ultrasound moves the phaco tip side to side, greatly reducing this repulsive effect and thereby allowing nuclear material to stay at the tip with lower settings. Even with settings as low as 20 mL/min or less of aspiration flow, 50 cm of bottle height, and 250 mm Hg or less of vacuum, the efficiency of torsional ultrasound for nuclear emulsification is still amazingly good.

In the presence of surgical challenges such as weak zonules, a posterior capsular rupture, or intraoperative floppy iris syndrome, torsional ultrasound allows us to adjust the fluidics parameters to maintain low pressure fluctuations and reduce turbulence. Reducing these energies helps to prevent vitreous prolapse or a floppy iris from being drawn to the phaco tip. Another benefit of lower fluidics settings is that a dispersive viscoelastic, which is injected to push back vitreous or iris (or to sequester a nuclear piece to prevent it from falling into the vitreous), is not aspirated and may further protect the delicate intraocular structures during complicated cases. In this way, a safe working distance can be maintained between

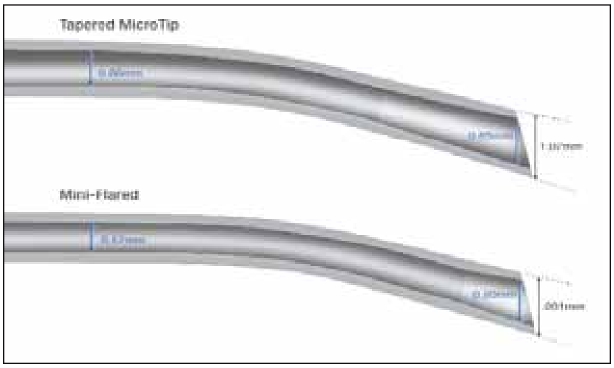

Figure 2. The 0.9-mm Mini-Flared Tip was specifically designed for micro-torsional techniques and offers better irrigation and improved stability. The 0.9-mm Kelman Tapered Tip's gently tapered shaft design allows enhanced lens followability and reduces potential clogging in dense lenses.

the phaco tip and the vitreous or a floppy iris. Thus, torsional ultrasound helps surgeons control difficult surgical situations and reduces complications, giving us much greater confidence.

Vacuum and Surge Protection

The contraction and expansion of aspiration tubing in response to vacuum occlusion breakage causes surge, which is the main culprit of anterior chamber instability. It is therefore optimal to minimize surge by reducing the compliance of a phaco system's aspiration tubing as much as ergonomically possible. Surge volume on occlusion breakage is significantly lowered with the INTREPID FMS compared with the INFINITI's original FMS (Figure 1). At the moderately high vacuum levels (300 to 400 mm Hg) currently used with the INTREPID FMS and torsional ultrasound, the surge flow volume is extremely low and thereby preserves the stability of the anterior chamber and raises the surgery's margin of safety, even when low bottle heights are necessary.

Dense Nuclei

Although counterintuitive, dense nuclei are a common surgical challenge that becomes easier with the lower fluidics settings and uncompromised efficiency of torsional ultrasound. The absence of repulsion in this system allows for very efficient and controlled emulsification of the hardest of lenses that were very difficult with longitudinal ultrasound. Furthermore, torsional ultrasound's reduced dependence on high aspiration flow limits turbulence and better retains more of the protective dispersive viscoelastic placed underneath the corneal endothelium, thereby producing clearer corneas postoperatively. Corneal decompensation is much more frequent in dense cataract cases, due to the prolonged surgery time and elevated levels of ultrasonic energy.

With very hard and rubbery nuclei, I prefer to use the 45° Kelman Tapered Tip, which has very little chance of clogging or stalling when using 100% torsional ultrasound. I have noticed that this tip is more efficient at repositioning and breaking up a nucleus than a 30° beveled tip (Figure 2). The 45° bevel of the tip has a larger surface opening that shears material even more efficiently with the side-to-side movement of torsional ultrasound. The 45° beveled tip allows the nuclear pieces to be repositioned while being emulsified, whereas a 30° beveled tip tends to core or drill into the nucleus.

Another challenge of very dense nuclei is their disassembly before emulsification. Although my routine procedure still involves a modified divide-and-conquer technique (what I call *fast crack phaco*), I switch to a chopping technique for very dense and rubbery nuclei, because these are very hard to divide into quadrants with a conventional cracking maneuver (see *Personal Settings*). A classic horizontal Nagahara chop technique is useful for chopping the nucleus into multiple smaller pieces, in my experience. Vertical chop techniques are another option.

To split a nucleus successfully, I recommend the following key points. (1) It is essential to grip the nucleus firmly prior to chopping it. Therefore, expose enough bare metal at the tip's end—the phaco tip should be able to drive deep enough into the nucleus to achieve a firm grip. (2) Burst mode is best for impaling the nucleus; 20- to 30-ms bursts of 50% fixed power are generally adequate. Although longitudinal ultrasound is theoretically best for drilling into the nucleus, torsional ultrasound also works well.

Figure 3. Torsional ultrasound helps surgeons control difficult surgical situations during nuclear fragment removal. The technology's minimal repulsive forces allow surgeons to use lower fluidics without sacrificing efficiency.

PERSONAL SETTINGS FOR DENSE CATARACTS WITH THE INTREPID FMS			
2.6 TO 2.8-MM INCISIONS **0.9-mm Tapered Tip and Micro Sleeve**		**2.2- TO 2.4-MM INCISIONS** **0.9-mm Tapered Tip and Ultra Sleeve**	
Chop (for impaling and chopping the nucleus only):		**Chop (for impaling and chopping the nucleus only):**	
Bottle height:	90 cm	Bottle height:	90 cm
Aspiration flow:	35 mL/min fixed, 2+ dynamic rise time	Aspiration flow:	25 mL/min fixed, 2+ dynamic rise time
Vacuum:	500 mm Hg fixed	Vacuum:	500 mm Hg fixed
Power:	burst mode, 20 ms, 50% fixed longitudinal ultrasound	Power:	burst mode, 20 ms, 50% fixed longitudinal ultrasound
Emulsification of Nuclear Fragments:		**Emulsification of Nuclear Fragments:**	
Bottle height:	90 cm	Bottle height:	90 cm
Aspiration flow:	25 mL/min linear	Aspiration flow:	15 mL/min linear
Vacuum:	300 mm Hg fixed	Vacuum:	300 mm Hg fixed
Power:	continuous mode, linear 100% torsional ultrasound	Power:	continuous mode, linear 100% torsional ultrasound

The chop setting on the INFINITI Vision System is also very useful for impaling and dislodging the first nuclear quadrant with a divide-and-conquer technique. The purpose of this setting is to grasp the first segment firmly and pull it to the middle of the anterior chamber. I then recommend that the surgeon change to a quadrant setting mode with continuous torsional ultrasound at a moderate-to-low level of vacuum.

It is important that any nuclear fragments are completely unattached from other fragments and mobile in order to be emulsified most efficiently with continuous torsional ultrasound. Whenever a quadrant is still slightly attached to another quadrant or is blocked by the iris/capsulorhexis edge, it cannot turn freely, and emulsification becomes less efficient. With longitudinal ultrasound's high-flow settings and repulsive effect, hard nuclear pieces are constantly repositioned and moved around. Torsional ultrasound with moderate settings is much more efficient, provided that nuclear fragments remain mobile (Figure 3).

INNOVATIVE IOL INJECTION SYSTEM

I think many surgeons' biggest hurdle to switching to micro-coaxial phacoemulsification in the past was the learning curve of IOL injection with the MONARCH II C cartridge (Alcon Laboratories, Inc.). Because the nozzle of the C cartridge was originally designed for in-the-bag insertion through a 2.8-mm incision, many surgeons' initial attempts at performing wound-assisted insertion through micro-incisions resulted in halted or failed IOL injections. The innovative MONARCH III D cartridge used in combination with the MONARCH III injector (Figure 4) will make the transition to a micro-coaxial technique much easier and enables the injection of a full 6.0-mm optic, single-piece, hydrophobic acrylic aspheric IOL through an unenlarged micro-incision (eg, the SN60WF IOL, Alcon Laboratories, Inc.).

Figure 4. The MONARCH III D cartridge and injector.

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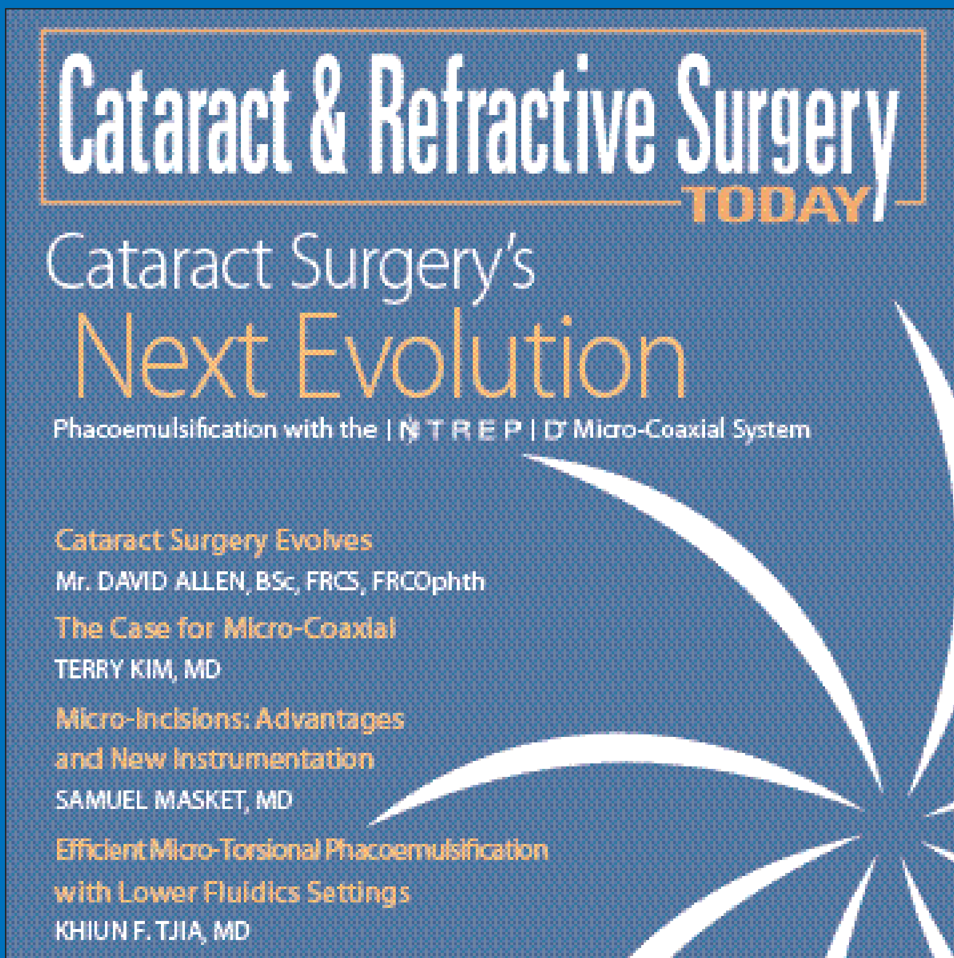

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