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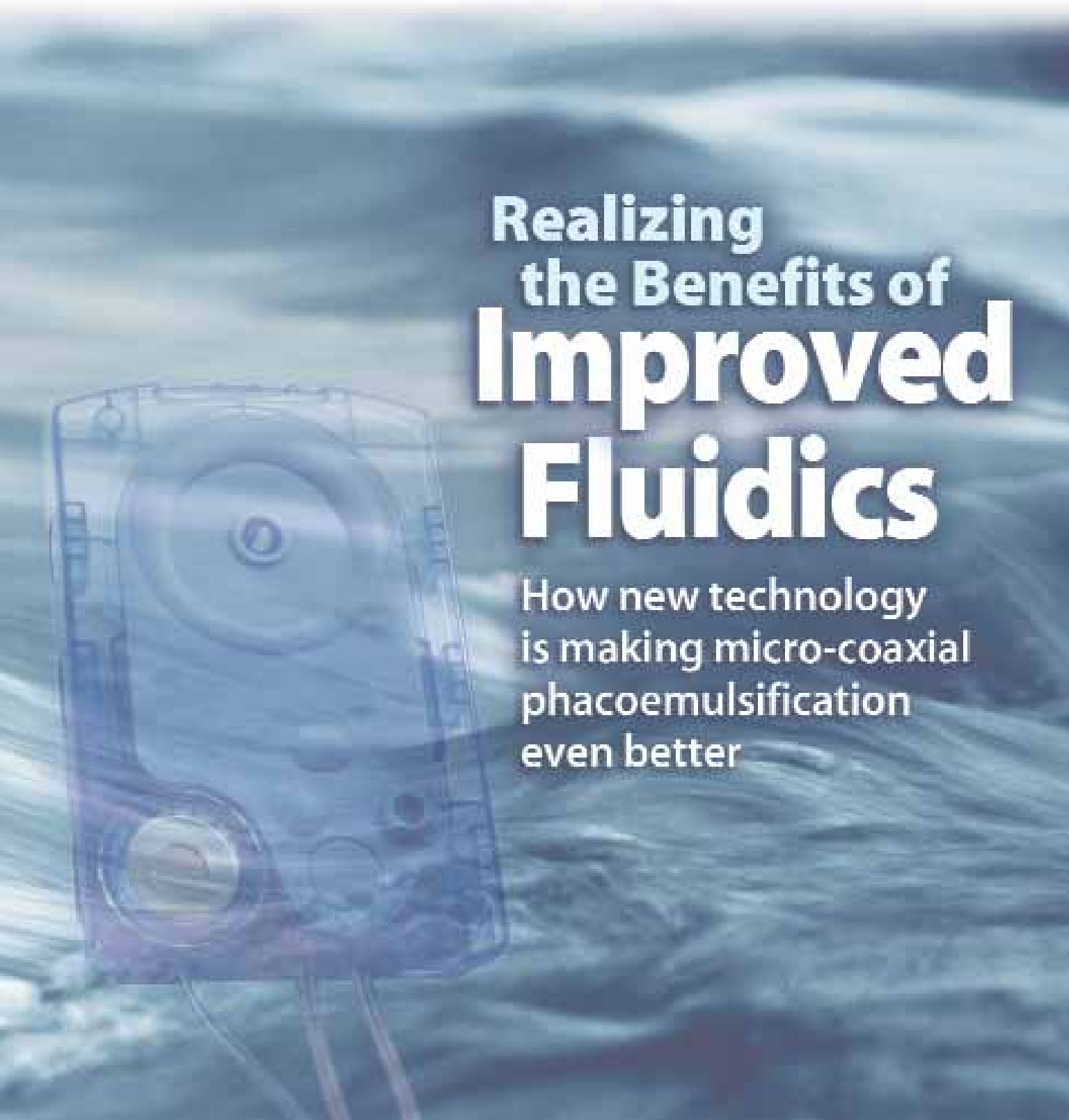

# Realizing the Benefits of Improved Fluidics

## How new technology is making micro-coaxial phacoemulsification even better

# Realizing the Benefits of Improved Fluidics

During the New Techniques and Controversies in Cataract and Refractive Surgery Meeting held in Park City, Utah, January 25 to 27, 2007, users of the Infiniti Vision System gathered to discuss the system's recent advancements, including the new Intrepid Micro-Coaxial Fluidic Management System (both from Alcon Laboratories, Inc., Fort Worth, TX).

## PARTICIPANTS

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My name is Robert Cionni, MD, from Cincinnati, and I am fortunate to be joined by several world-renowned ophthalmologists: Stephen Lane, MD, from Minneapolis; Terry Kim, MD, from Duke University (Durham, NC); and David Allen, BSc, FRCOphth, from Sunderland, England. In addition, we have Grace Liao, MS, who is Associate Director of Research and Development with Alcon Laboratories, Inc., and who has participated in developing the fluidics of the company's various phaco platforms.

## ADVANCES IN CATARACT SURGERY

**Dr. Cionni:** What do you think have been some of the most important advances in cataract surgery over the past several decades?

**Dr. Lane:** Cataract surgery has benefited from many small, incremental changes that have led to major advances. Just when we think the field cannot get any better, surgeons working with industry come up with new innovations that take the specialty another step further. When I first started performing cataract surgery, I used fixed-power phacoemulsification. Linear phaco power, which allowed the surgeon to control the amount of ultrasound power delivered into the eye, was a tremendous evolution that we thought could not be surpassed. Obviously, phaco technology has continued to improve. Furthermore, recent strides in ultrasound technology have produced torsional technology, which may someday replace traditional longitudinal ultrasonic power, although longitudinal ultrasound remains the dominant form of phaco energy for now. Improvements such as these have been very positive for cataract surgery.

**Dr. Cionni:** Mr. Allen, you were practicing at the time of extracapsular surgery. Can you talk about the improvements made since those days?

**Mr. Allen:** I actually was practicing in the days of intracapsular cataract surgery, and I remember the transition to extracapsular surgery during the 1980s. At that time, I thought that cataract surgery had peaked, and that the envelope capsulotomy and endocapsular removal represented the ultimate surgery. Of course, what has happened since then has been amazing.

During the past 20 years, the efficiency and safety with which we remove cataracts has improved exponentially. I recently studied a series of surgeries to look at the efficiency of different phaco tips and noted that the average time it took to remove the cataract, from the initiation of sculpting to extracting the entire epinucleus, was as low as 80 seconds. This is a dramatic change from the 1980s, when surgeons would spend 10 minutes removing the cataract and implanting the lens and another 10 minutes suturing the incision. Of course, we no longer have to resuture the incision, which saves a lot of time.

**Dr. Cionni:** Dr. Kim, what other small, incremental changes over the past 10 years do you think have improved the efficiency and safety of cataract surgery?

**Dr. Kim:** I entered into training when phacoemulsification was widespread and the primary method of removing a cataract. Since then, our understanding of phaco dynamics and power modulation has improved immensely.

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> —Stephen S. Lane, MD

When I started, I was using the Legacy Phacoemulsification System (Alcon Laboratories, Inc., Fort Worth, TX) with a 5-mm clear corneal incision. Recently, I have become very excited about torsional ultrasound in particular; I think it represents another major advance in cataract surgery. I also think that torsional technology pairs extremely well with the new 2.2-mm micro-coaxial incision. Certainly, we have seen how innovations in IOL technology have spurred advancements in phacoemulsification, and vice versa, and I think these advances point to a bright future.

**Dr. Cionni:** Cataract surgery has certainly become more efficient as well as safer over the years. Surgeons have not improved—I am not any more skilled than my predecessors—but the techniques have advanced. We stand on others' shoulders to see farther. In addition, cataract surgery equipment has advanced tremendously.

I began my surgical career performing extracapsular cataract extraction. I had operated on approximately 60 eyes with this technique and never lost vitreous. When phacoemulsification emerged, I was one of the first residents to have access to this technology. Although I was excited to use it, I lost vitreous in almost one-third of my cases. The capsule would come forward, the chamber would collapse, and I would break the capsule. I was so upset by

these outcomes that I almost decided to go into neuro-ophthalmology, and was fortunately talked out of it by Robert Osher, MD. Why did I have so much difficulty? It was not because I was a terrible surgeon. Rather, the technology was not as advanced as it is now. The biggest flaw of early phaco machines was surge.

## SURGE

**Dr. Cionni:** Let me describe surge, because I think many surgeons are still confused about what causes it. Whenever outflow is greater than inflow, the anterior chamber will collapse. This potential situation occurs in every single cataract case when either the phaco tip or the I/A tip is occluded by a nuclear fragment and vacuum builds. The moment that the occlusion breaks, a sudden rush of fluid comes into the tip to satisfy the vacuum left in the various components of phaco tubing and cassettes.

Surge is also affected by high flow. To combat increased outflow, we raise the irrigation bottle higher and higher. Elevating the bottle increases IOP and expands the globe. However, this elevated IOP coupled with the machine's building vacuum and the tendency of the elastic globe to expand and collapse during phacoemulsification exaggerates surge caused by occlusion breaks.

**Dr. Lane:** I would like to expand on that thought. When describing surge to ophthalmic residents, I use a simplistic analogy that helps them understand the concept. I tell them to imagine a flexible or highly compliant soda straw. If you put your finger over one end of the straw and place the other end in your mouth and suck on it, the plastic collapses. Then, if you suddenly release your finger from the bottom end of the straw, air rushes into your mouth. This is how surge works. As Dr. Cionni just stated, raising the bottle height higher is one way to mask or combat surge. However, preventing the soda straw from collapsing would be a better solution, because it would allow us to use more reasonable levels of inflow, which decrease ocular expansion and potential turbulence.

**Dr. Cionni:** Phaco machine manufacturers have attempted over the years to decrease surge with certain improvements such as MaxVac tubing and ABS (aspiration bypass system) tips (both by Alcon Laboratories, Inc.). The ABS tips were made with a hole that decreased vacuum levels that would help prevent collapse of the anterior chamber. Also, flared tips or tips with smaller inner diameters that increased fluidic resistance during occlusion break became widely used during the last 10 years. Even with these improvements, however, surgeons still experience some surge today.

Dr. Lane, you used the Legacy before the Infiniti. How did the improvements in fluidics in the Infiniti help you when you switched from the Legacy?

**Dr. Lane:** The Legacy represented a dramatic improvement over the previous-generation phaco technologies, and certainly the Infiniti improved upon the Legacy. Regarding fluidics specifically, the Infiniti has accomplished a number of things. First, the Infiniti has a more rigid cassette and pump system that helps reduce surge. The Infiniti also gives surgeons more options and control over the fluidics software than we had with the Legacy. The concept of rise time, which was fairly new to a peristaltic type of pump, allowed users to mimic to some degree the type of responses previously seen only with Venturi pump systems. The faster acceleration of the aspiration flow rate and the faster buildup to higher levels of vacuum makes surgery more efficient but also has the potential to increase the amount of surge caused by obtaining high vacuum more quickly.

> "Raising the bottle height higher is one way to mask or combat surge. However, preventing the soda straw from collapsing would be a better solution."
>
> —Stephen S. Lane, MD

## NEW FLUIDICS DECREASE SURGE

**Dr. Cionni:** Ms. Liao, will you please expand on how Alcon engineers have created a new fluidics design to help us suppress surge even better than what the Infiniti can do today?

**Ms. Liao:** I would like to start with Alcon's design goals for the Intrepid Fluidic Management System (FMS). First, my fellow engineers and I wanted to enhance the system's fluidic performance, specifically for micro-coaxial techniques. Because smaller incision sizes decrease irrigation flow, our primary goal was to maximize chamber stability. We aimed to reduce surge after an occlusion break as well as enhance the fluidic response of the system.

We focused on two concepts when redesigning the Infiniti's fluidics. One was to minimize compliance of the


**Figure 1. This graph demonstrates that low-compliance (rigid) systems are affected less by various vacuum pressures.**

aspiration tubing. This change alone reduces post-occlusion surge and enhances the vacuum response. Second, we wanted to enhance irrigation as a component of minimizing surge.

A volume-versus-pressure curve can detail compliance (Figure 1). By graphing the change in volume over the change in pressure or vacuum, the slope of these curves demonstrates compliance. The stiffer curve has a much lower slope, indicating fewer changes in volume or a corresponding change in pressure versus a much more compliant line. Such a graph helps us measure the performance of our phaco consumables and how they will respond to surge.

We measure occlusion surge amplitude in millimeters of mercury (mm Hg), and the occlusion surge area as a function of the amplitude, or height, of the surge, as well as a component of the duration of the surge. The occlusion surge area correlates with the potential outflow that can occur after an occlusion break. We have measured the new Intrepid FMS fluidics against our existing design. Even at 400 mm Hg, which is a typical vacuum setting used in surgery, the Intrepid has half of the occlusion break surge compared with the current FMS (Figure 2).

With the lack of contraction and expansion of the stiffer aspiration tubing, vacuum rise time (surgical response) is slightly improved. Figure 3 (page 6) shows that the existing Infiniti System takes approximately 0.80 seconds to achieve 400 mm Hg of vacuum, compared with approximately 0.50 seconds with the Intrepid Micro-Coaxial FMS.

**Dr. Cionni:** I fully agree. Ms. Liao, what happens to flow rates with small phaco incisions in bimanual and micro-coaxial, and why will manufacturers have to begin targeting the source of surge in response to the irrigation flow?

**Ms. Liao:** We have designed the Infiniti's infusion sleeves to maximize infusion flow at many different incision sizes. As incision sizes decrease from 3.2 mm to 1.8 mm, the irrigation flow naturally decreases. Surgeons have had to compensate for this reduced flow with micro-coaxial techniques by either lowering their parameters for flow and vacuum or by elevating the bottle. As you have all described, however, this strategy is not optimal for certain patients and surgical techniques. By lowering the compliance of the overall aspiration line, the Intrepid Micro-Coaxial FMS provides surgeons with the flexibility to better choose the bottle heights and parameters they need for every surgical case and also improves chamber stability for micro-incisional techniques.

One challenge posed by enhanced irrigation is that micro-coaxial techniques inhibit flow and thereby limit the surgeon's ability to use irrigation to minimize and overcome surge. Also, increasing irrigation can have an ergonomic impact by changing the way the tubing feels and moves for the surgeon. Other fluidic designs have experimented with increasing the dimensions of the irrigation tubing, but doing so increases the amount of fluid volume needed for priming, lengthens the priming time, and adds weight and volume into the line, which can impact the handpiece's mobility. Most importantly, we

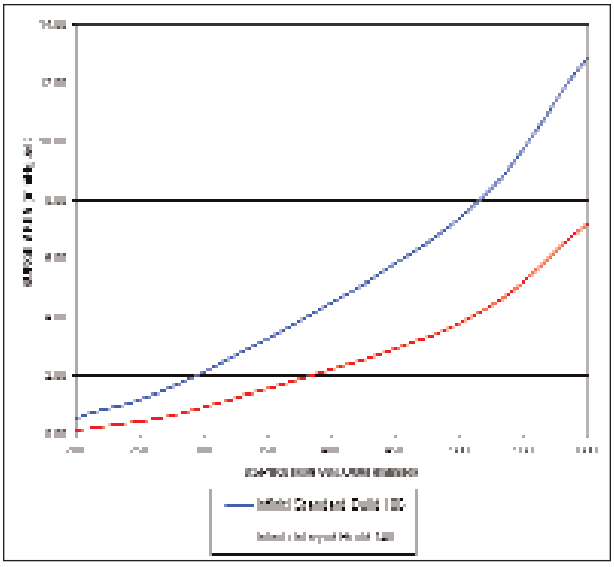

**Figure 2. This graph shows that the post-occlusion surge area is reduced by almost 50% with the new Intrepid FMS.**

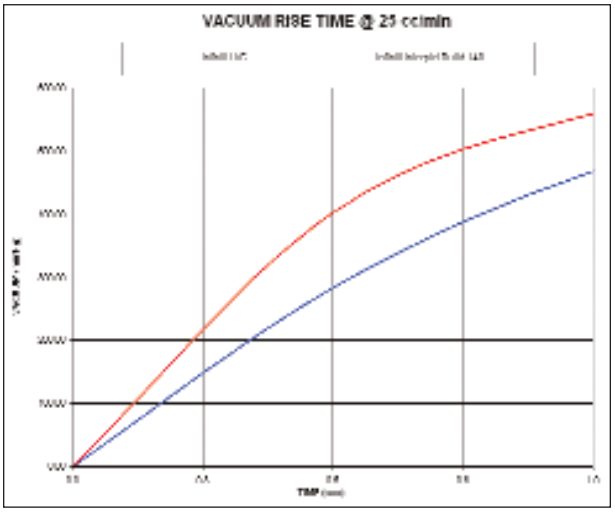


**Figure 3. This graph shows that vacuum rise time is slightly improved with the Intrepid FMS.**

had to consider the ergonomic impact of stiff, low-compliance tubing for the surgeon, and we were careful to accommodate the surgeon's dexterity during surgery.

**Dr. Cionni:** So, if we raise the bottle to combat decreased inflow, then we can bring more fluid into the eye, but it comes in under a higher pressure. That inflow creates a more turbulent environment inside the eye. The stiff tubing in the Intrepid FMS system reduces compliance, which is the biggest cause of post-occlusion surge.

Ms. Liao, how important was it to stiffen all components of the system? In other words, could this be done just in the cassette or the tubing, or did it have to be done throughout the system?

**Ms. Liao:** It had to been done throughout the entire system. My team examined reducing compliance in each area of the Infiniti system, but we found that reducing it in only one area did not have the same effect.

## MICRO-INCISIONAL PHACOEMULSIFICATION

**Dr. Cionni:** Mr. Allen, you have been performing micro-incisional phacoemulsification with the Infiniti. Please share your experience.

**Mr. Allen:** Micro-incisional surgery can significantly reduce inflow. As we already discussed, we want the inflow to compensate for the surge in outflow when occlusion breaks. As the surgeon reduces the diameter of the irrigation sleeve to allow the inflow to pass through a small incision, the resistance to inflow increases significantly—by the fourth power of the radius change. In response, when I perform micro-incisional phacoemulsification with existing Infiniti cassettes using a straight needle with no flow restrictions, such as the 0.9-mm MicroTip (Alcon Laboratories, Inc.), I drop my vacuum level to 350 mm Hg (I previously used a maximum vacuum of 450 or 475 mm Hg with 2.8-mm incisions) at a bottle height of 110 cm. With the Intrepid FMS, I have been incrementally increasing the vacuum again. I am now up to my previous levels and see no worrisome surge. Using Intrepid and flared tips, it may be possible for me to reach above 500 mm Hg. In summary, the Intrepid FMS has more than compensated for the greater inflow reduction of small-incision surgery.

**Dr. Cionni:** You make an excellent point, that those of us who have been using the Infiniti with a 2.8- to 3.2-mm incision may not notice a huge difference when transitioning to the Intrepid system unless we increase the vacuum limit. When we use micro-incisional phacoemulsification on the existing platform, we have to decrease our vacuum and flow rates somewhat because of the decreased inflow. With the Intrepid FMS, we can bring those parameters back up. I appreciate the efficiency of performing phacoemulsification with higher vacuum once again.

Dr. Kim, what do you think the Intrepid FMS will mean in terms of efficiency and safety for your patients?

**Dr. Kim:** I expect the Intrepid system to offer a big advantage in safety and efficacy. I had the same experience as all of you when I transitioned to micro-incisional phacoemulsification and then to the Infiniti with Intrepid FMS. In going to 2.2-mm incisions with the previous Infiniti Vision System, I had to decrease all of my settings by about 20%. With the Intrepid Micro-Coaxial FMS, I can be more aggressive with my flow and vacuum settings and still maintain anterior chamber stability equal to what I had with my standard 2.8-mm incisions. I tend to be a high-vacuum, high-flow surgeon; I mostly incorporate phaco chop and prechop techniques. The Intrepid FMS offers surgeons who use these techniques a big advantage with rapid rise time, which increases the holding force, as well as suppression of post-occlusion surge. The residents and fellows I train always want to learn the latest and greatest in surgical techniques and technologies without sometimes knowing or understanding the phaco dynamics that drive them. I think this Intrepid system of products has added another level of safety and efficacy to phacoemulsification, and particularly to micro-incisional techniques, that will benefit

surgeons transitioning to these newer techniques and instrumentation.

**Dr. Cionni**: I think the key word is *control*. We need the ability to control our environment within the eye. Smaller amounts of surge deliver better control in every single case.

## FLUIDIC NEEDS IN CHALLENGING CASES

**Dr. Cionni:** What about challenging cases like loose zonules and intraoperative floppy iris syndrome (IFIS)? Mr. Allen, you have tremendous experience with dense lenses. Will you tell us what improved control and decreased surge means to you, specifically with a dense cataract?

**Mr. Allen:** With dense cataracts, perhaps what physicians (and certainly, surgeons in training) fear most is the small amount or complete lack of epinucleus and cortex in these types of cases. Whenever the surgeon is manipulating large, hard, brunescent cataracts, they are always aware that just behind it is the bare capsule; there is no protective shell of cortex and epinucleus. Once a surgeon has experienced the benefits of the new Intrepid FMS and feels comfortable that there is no significant decrease in the anterior chamber's volume following post-occlusion surge, it gives him additional confidence to break up hard nuclei. If the surgeon is using a sculpting technique, it means he can sculpt right down to that very dense posterior nuclear plate. Actually, sculpting through the leathery posterior part of the nucleus is vital, otherwise the nucleus will not crack. It also means that he can continue to use high vacuum and flow settings, which are very important when trying to remove hard cataracts with minimal phaco energy and fluid going through the eye. The high vacuum settings possible with this system do not significantly impact very soft cataracts, but they do make a difference with hard nuclei, even with torsional ultrasound.

> "I think the key word is *control*. We need the ability to control our environment within the eye. Smaller amounts of surge deliver better control in every single case."
> —Robert J. Cionni, MD

The assurance of being able to use a flow rate of 40 mL/min and a vacuum of 450 or 500 mm Hg with a Mini-Flared ABS tip and not worry about unmanageable surge makes a tremendous difference during phacoemulsification. I think this capability will be particularly helpful for surgeons in training, who are always afraid to go deeply enough to split and chop the nucleus efficiently. If one cannot perform that step effectively, then the entire procedure goes out of control.

> "The high vacuum settings possible with this system do not significantly impact very soft cataracts, but they do make a difference with hard nuclei, even with torsional ultrasound."
> —David Allen, BSc, FRCOphth

**Dr. Cionni:** With most routine micro-coaxial cataract cases, there is some room for error, but not with dense lenses. Thus, having a system that gives more precise control inside the eye is very important.

**Dr. Lane:** As we talk about creating equilibrium between the amount of fluid traveling in and out of the eye so that a steady state is attained, we touch on the topic of the risk of inducing thermal injury. Although surge is a critical issue, I think thermal injuries are occurring at a much higher rate than is being reported during micro-incisional procedures with all different phaco systems. Some wound burns may be subclinical, meaning there is subtle thermal damage that causes some wound instability and leakage and may increase the potential for endophthalmitis. Again, maintaining fluidic equilibrium within the eye is very important for minimizing and hopefully eliminating any potential for thermal injury, especially when working through small incisions that close tightly around the vibrating phaco needle.

**Dr. Kim:** I think Dr. Lane raises a great point. We may not be seeing frank wound burns clinically, but we can see a phenomenon called *incisional molding*, which refers to altered corneal wound architecture due to mechanical stress and increased thermal temperatures from the phaco probe. All cataract surgeons are concerned about whether clear corneal incisions are directly associated with endophthalmitis, and I think incisional molding that can occur with incisions that are too small can compromise the sealing of these wounds and increase the potential for wound leakage and subsequent contamination.

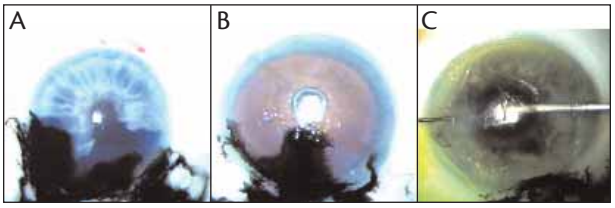


**Figure 4. Observation through the operating microscope shows gross evidence of India ink's penetration into the anterior chamber of an eye that underwent micro-incisional bimanual phacoemulsification (A), but no evidence of India ink in the anterior chamber of an eye that underwent micro-incisional coaxial (B) or standard coaxial (C) phacoemulsification.**

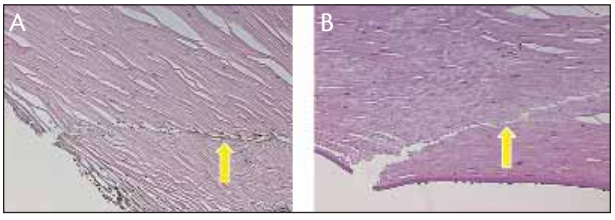


**Figure 5. Histopathologic examination reveals evidence of India ink particles along the wound tract of the bimanual 1.2-mm incision (A, arrow) but not in the wound tract of the micro-coaxial 2.2-mm incision (B, arrow).**


**Figure 6. Scanning electron microscopic examination demonstrates qualitatively greater endothelial 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.**

To prove this point, my colleagues and I performed a prospective study using human cadaver eyes to compare the effects of phacoemulsification on clear corneal incisions' architecture and wound integrity.[1] We divided these eyes evenly to undergo simulated phacoemulsification (all phaco settings were kept constant in each group) using one of the three following modes: micro-incisional bimanual phacoemulsification (two 1.2-mm incisions), standard coaxial phacoemulsification (2.75-mm incision), and micro-incisional coaxial phacoemulsification (2.2-mm incision). We observed spontaneous wound leakage in five out of five eyes that underwent bimanual phacoemulsification, in one out of five eyes (20%) that had standard coaxial phacoemulsification, and zero of five eyes that had micro-coaxial phacoemulsification. India ink penetration through the wound and into the anterior chamber was evident in two out of two eyes that underwent bimanual phacoemulsification, one of two eyes that had standard coaxial phacoemulsification, and zero of two eyes that underwent micro-incisional coaxial phacoemulsification, both on gross observation (Figure 4) and histopathologic examination (Figure 5). Scanning electron microscopy revealed increased endothelial cell loss and a greater compromise to Descemet's membrane when comparing bimanual phacoemulsification to standard coaxial phacoemulsification and micro-incisional coaxial phacoemulsification (Figure 6). The results in this experimental setting support the hypothesis that micro-incisional bimanual phacoemulsification (which does not utilize protective infusion sleeves) induces more wound stress and alteration of wound morphology than micro-incisional coaxial phacoemulsification and standard coaxial phacoemulsification, probably due to increased incisional molding.

**Dr. Cionni:** Dr. Lane, please tell us about the patient who has missing zonules or a posterior polar capsule. These are cases in which we do not want a lot of fluid moving through the eye. How would the Intrepid FMS help in these particular eyes?

**Dr. Lane:** The benefits of reducing irrigation fluid and resulting ocular pressure in routine cases carry through to complicated cataract cases. As a surgeon, you want to know that you have control over the phaco system and how to use it. We must learn those skills to optimize on what the machine has to deliver. Before significant changes in the tubing compliance occurred, certain mechanisms

> "I am not suggesting that the Infiniti's new fluidics will eliminate IFIS, but they may lead to better outcomes with fewer complications for these difficult cases."
>
> —Terry Kim, MD

developed to counteract surge restricted users' degree of control. ABS is one example; it is a clever tool to try to reduce surge, but it also decreases efficiency by diminishing the surgeon's ability to physically grasp lens material as fluid travels through those holes. Now that we are working through tighter incisions and using smaller tips, we need other ways to control surge.

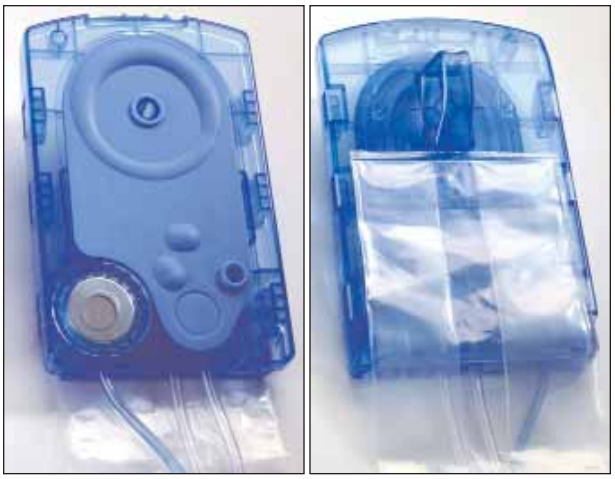

**Figure 7. The Intrepid FMS has less compliant aspiration tubing (signified by the blue line), which helps suppress the cause of post-occlusion surge.**

Smaller tips also decrease our control over phaco surgery because their reduced surface area is less efficient at occluding nuclear material. This compromise becomes important in eyes with loose zonules, where we must liberate the lens from its capsular attachments and dissect it with minimal fluidic impact to the rest of the capsule. Because the Intrepid FMS allows all different types of phaco tips to grasp, hold, and extract fragments more efficiently than previous-generation phaco systems, it minimizes our need to manipulate or turn nuclear material, which can stress the zonules during these difficult cases.

**Dr. Cionni:** Certainly, whenever there is a direct opening between the anterior and posterior segments, there is the possibility of chamber collapse inviting vitreous prolapse. If we can maintain a deep chamber without having to raise the bottle too high, we will decrease the risk of vitreous prolapse.

**Dr. Kim:** I have noticed some differences with the Intrepid FMS in terms of its effect on the dilated iris, particularly in cases with IFIS. There are varying degrees of IFIS, but usually these irides start constricting during post-occlusion surge. The chamber fluctuates and then the iris starts to come down. The Intrepid FMS minimizes post-occlusion surge (Figure 7) and improves surgical response, thereby enhancing the environment for removing these cataracts. I am not suggesting that the Infiniti's new fluidics will eliminate IFIS, but they may lead to better outcomes with fewer complications for these difficult cases.

**Mr. Allen:** Another clinical reason to minimize the fluctuations resulting from very high IOP due to surge from a high bottle height is to prevent vitreous traction on the macula. This complication can increase the potential for a breakdown in the blood/retinal barrier and invite cystoid macular edema (CME). Although it is difficult to prove a correlation with pressure fluctuations scientifically, I think a lot of physicians feel that fluctuations in pressures and volumes within the anterior chamber are transmitted to the posterior chamber. We would expect to see a reduced incidence of problems such as CME after cataract surgery if we minimize the fluctuations.

**Dr. Cionni:** That is a very good point. Although, as you said, the connection is hard to demonstrate, it makes sense that vitreous tugging in a fluctuating fashion on the retina might induce a higher incidence of CME.

## SETTING CHANGES

**Dr. Cionni:** Let's talk about specific settings. When I moved to micro-coaxial surgery with the mini-flared tip, I had to reduce my vacuum power from 450 mm Hg to below 400 mm Hg and decrease my flow rate from 40 to 30 mL/min. I also raised my bottle from 90 to 100 cm. I did not like any of these changes, but I loved using the smaller incision. Since using the Intrepid FMS, I have been able to return to my previous parameters.

Dr. Lane, can you talk about your specific parameters and the changes you made as you transitioned to micro-coaxial, and then what you could do once you started using the Intrepid FMS?

> "With the Intrepid FMS, I have brought all my parameters back to where I like them."
> —Stephen S. Lane, MD

**Dr. Lane:** My parameters for phacoemulsification were basically the same as yours, and I found I had to lower them all when I started using micro-coaxial phacoemulsification. I previously worked at 450 to 500 mm Hg of vacuum, and with micro-coaxial, I was using 350 to 400 mm Hg. I lowered my aspiration flow rate from 35 or 40 mL/min to around 30 mL/min, and I had to raise my bottle to 100 cm. With the Intrepid FMS, I have brought all my parameters back to where I like them. My bottle height now is approximately 90 cm, my flow rate is back up to near 40 mL/min, and my vacuum

level is roughly 450 mm Hg, depending on the surgery I am performing.

I also think the Intrepid system has improved my surgical efficiency. When I was using torsional phacoemulsification with my pre-Intrepid parameters, I was experiencing occasional problems with clogging of the phaco tip. As a consequence of the lower vacuum and depending on the density of the lens, I was having to back off the torsional and blend in more longitudinal ultrasound in order to break up the lens without clogging. With the Intrepid system, I see much less clogging, and I am able to use 100% torsional ultrasound more often for the same density of lens. This is an advantage to me because I am thrilled with the cutting performance and lack of repulsion of torsional ultrasound.

**Dr. Kim:** When I moved to the 2.2-mm micro-coaxial incision with torsional ultrasound, one of the things I noticed immediately was that, with the MicroSmooth Ultra Sleeve (Alcon Laboratories, Inc.), I did not see much leakage around the incision. I think a tightly sealed incision translates into a more stable chamber. Also, this size of incision seemed to enhance the fluidics and the followability of the surgery. The entire combination has been a great improvement. Before the Intrepid FMS, I decreased all my settings by roughly 15% to 20%, but with the Intrepid System, I was able to raise my vacuum back to about 420 mm Hg, my aspiration flow rate to 45 mL/min, and my bottle height to 110 cm. I appreciate not having to change my flow parameters now that I am using a 2.2-mm incision.

> "With this stiffer tubing, surgeons may think they need more of it to be loose for movability, but this is not the case."
> —David Allen, BSc, FRCOphth

**Mr. Allen:** My experience has been the same. I initially reduced my parameters, and with the Intrepid FMS, I have put them back up again. Furthermore, I can take the vacuum power even higher, to 500 mm Hg or more, if I use the mini-flared tip (which has flow restriction on it) with OZil Torsional ultrasound (Alcon Laboratories, Inc.) and a 2.2-mm incision. For challenging cases that call for high vacuum, the combination of the Intrepid FMS and the slight restriction in outflow from the mini-flared tip provides especially efficient phacoemulsification and high vacuum. I have been very pleased.

## ERGONOMIC DIFFERENCES

**Dr. Cionni:** You have all discussed how the Intrepid FMS has made your procedure safer and more efficient. Are there any downsides to using this new fluidics system? How does the stiffness of the tubing feel? Do you notice it, and does it limit your ability to perform surgery the way you want to?

> "The Intrepid Micro-Coaxial FMS is certainly a strong step forward in providing one more layer of protection for our patients."
> —Robert J. Cionni, MD

**Dr. Lane:** The Intrepid FMS ergonomics are certainly different. With previous systems, we were used to having the silicone tubing wrap around our wrist and forearm area. If we pulled the tubing a little bit, it gave very nicely. If the machine were perhaps a little far away, you could simply move the handpiece a little more and get more slack. The Intrepid FMS system's rigid tubing does not have great flexibility. It does not drape over your forearm and wrist in the same manner. To some extent, this rigidity is an advantage, because the tubing is less likely to curl and become entangled. The tubing is particularly stiff where it enters the handpiece. I could easily overcome the restriction I felt with the FMS system by using just a little more force. I also had to compensate for this slight restriction while performing other maneuvers, but it was not a big deal. I was accustomed to the difference by the middle of my second case. I noticed the difference more with I/A, because I manipulate the I/A handpiece quite a bit under the capsule—up to 360° to extract residual cortex, etc. Again, I got used to the new movement quickly.

**Dr. Kim:** The tubing did not have much of an effect on my surgical ergonomics. Like Dr. Lane, I noticed the difference more with I/A, but not to the point that I had to change my technique or positioning. The biggest ergonomic differences I encountered when using micro-incisional surgery with torsional phacoemulsification was with switching from a 0.9-mm tapered tip that had a straight shaft to a 0.9-mm mini-flared Kelman tip with a 22° angulation of the shaft

and a 45º cutting tip. I found that I had to adjust the positioning of my hand during impalement of the nucleus and during retrieval of nuclear fragments. Overall, I experienced a very short learning curve and found this new tip to be very expedient and effective for removing both routine and dense cataracts using phaco chop techniques with torsional ultrasound through a 2.2-mm incision.

**Dr. Cionni:** So you and Dr. Lane agree that the FMS fluidics tubing is a little stiffer but not an issue. How about you, Mr. Allen?

**Mr. Allen:** The stiffness is not a big issue. The first people to notice it are the scrub nurses as they are prepping the machine. With this stiffer tubing, surgeons may think they need more of it to be loose for movability, but this is not the case. The radius of curvature of this stiffer tubing is much greater than the previous design, and therefore we do not need a lot of additional movement to take advantage of changes in the orientation of the handpiece. People often expect tools that are different to be difficult to use, but in practice, this new design is not. In fact, I found one significant advantage with this design. I operate in two different ORs that are each set up differently. In one of the rooms, there is an uncomfortable gap between my operating platform and the instrument's position. It was quite easy to drop the traditional tubing into that gap and potentially contaminate it, but this does not happen with the stiffer tubing. I suggest that surgeons try the new system for one case, and they will find that the learning curve is small.

**Dr. Cionni:** I agree with all of you. The first time I used a phaco handpiece with the Intrepid FMS tubing, I noticed it was stiffer, so I performed an experiment where I asked my scrub nurse not to tell me which system I was using to determine if I could tell which was which. Over the course of 1 day, I identified the cassette correctly about 50% of the time. Once you get used to using the Intrepid FMS system, you cannot tell the difference unless you are manipulating the handpiece a lot.

**Dr. Lane:** I like to use bimanual I/A a lot, and I can certainly tell the difference then, because the irrigation and aspiration are unlinked. There is some difference in the stiffness between those two tubes, but again, it is not a big deal.

**Dr. Cionni:** We have had a good discussion here today, and I think we all agree that fluidics are integral to a safe cataract procedure. Although with every step forward, we may think that surgical technology cannot possibly improve further, there is always room for improvement. I would like to applaud Alcon Laboratories, Inc., for continuing to focus on reducing surge in phaco systems. The Intrepid MicroCoaxial FMS is certainly a strong step forward in providing one more layer of protection for our patients. ■

1. Berdahl JP, DeStafeno JJ, Kim T. Corneal wound architecture and integrity after phacoemulsification: evaluation of coaxial, microincision coaxial, and microincision bimanual techniques. *J Cataract Refract Surg.* 2007;33:3:510-515.