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INNOVATIONS IN PHACOEMULSIFICATION DEVICES AND TECHNIQUES IN 2021

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CONTENT SOURCE

This continuing medical education (CME) activity captures content from a virtual roundtable.

ACTIVITY DESCRIPTION

This supplement describes the differences between phaco pumps, innovations in phaco, and how to use techniques in complex cases.

TARGET AUDIENCE

This certified CME activity is designed for cataract surgeons.

LEARNING OBJECTIVES

Upon completion of this activity, the participant should be able to:

- **Discuss** the differences between peristaltic and venturi pumps including advantages, disadvantages, and safety and efficacy data
- **Identify** the benefits and challenges of recent innovation in phacoemulsification systems and techniques
- **Assess** phacoemulsification techniques and approaches and **apply** best practices for challenging cases to increase visual outcomes and patient satisfaction

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PRETEST QUESTIONS

PLEASE COMPLETE PRIOR TO ACCESSING THE MATERIAL AND SUBMIT WITH POSTTEST/ACTIVITY EVALUATION/ SATISFACTION MEASURES FOR CME CREDIT.

1. Please rate your confidence in your ability to describe innovations in phacoemulsification systems (based on a scale of 1 to 5, with 1 = "Not at all confident" and 5= "Very confident").

A. 1
B. 2
C. 3
D. 4
E. 5

2. What one innovation in phacoemulsification has had the greatest impact on the safety and efficacy of cataract surgery?

A. Active fluidics
B. Occlusion mode
C. Inflow regulating software
D. Aspiration monitoring

3. Which statement best describes the difference between peristaltic and venturi pumps?

A. Peristaltic pumps are flow based, venturi pumps are vacuum based
B. Peristaltic pumps are regulated by physical structures, venturi pumps are fine-tuned through circumstances within the surgery
C. Venturi pumps create flow through rollers, peristaltic pumps use vacuum to create flow
D. Venturi pumps have higher vacuum levels than peristaltic pumps

4. In what clinical situations is the venturi most advantageous? Select all that apply.

A. Dense lenses
B. Small pupils
C. Intraoperative floppy iris syndrome
D. During a 4-quadrant split

5. How is the Veritas Vision System different from other systems currently on the market?

A. The Veritas is the first system with forced infusion
B. The Veritas has active fluidics technology that monitors pressure in real time
C. The Veritas uses an advanced linear foot pedal to transition between peristaltic and venturi pumps
D. The Veritas is a dual pump system, allowing surgeons to switch between venturi and peristaltic pumps on demand

6. In what clinical situation is the Zepto useful?

A. The Zepto creates a perfectly round capsulotomy for surgeons without a femtosecond laser
B. The Zepto is designed to help chop extremely dense cataracts
C. The Zepto is a pupil-expanding device for poorly dilating or small pupils
D. The Zepto is useful for managing patients with floppy iris syndrome

7. What is the "zone of safety" for cataract surgery?

A. In the middle of the pupil
B. In the anterior chamber
C. Equidistant from the posterior capsule, iris, and corneal endothelium
D. In the posterior chamber

8. When managing an extremely dense cataract, what tool is always necessary to maximize success?

A. Trypan blue
B. miLOOP
C. Malyugin ring
D. Healon EndoCoat viscoelastic

9. According to the literature, which pump is the "best" for cataract surgery?

A. Peristaltic
B. Venturi
C. There is no "best" pump modality; it depends on the situation

Innovations in Phacoemulsification Devices and Techniques in 2021

Cataract surgery is a life-changing procedure that improves visual acuity and quality of life. After more than 50 years, phacoemulsification (phaco) remains the dominant method for cataract removal in the United States.[1] Phaco has withstood the test of time for good reason; it consistently achieves better outcomes than manual extracapsular cataract extraction.[2] Although phaco is not new, ongoing innovations in systems, devices, and techniques have increased the safety and efficacy of surgery, making phaco a highly customizable procedure. Modification of phaco power duration and osculating tips optimize phaco energy during surgery.[3,4] Increasing inflow, decreasing outflow, and surge modulation reduce occlusion break surges.[5,6] Next-generation foot pedals and phaco tips give surgeons better control and reduce ultrasound time, increasing safety and anterior chamber stability and lowering the risk of endothelial cell loss, wound burn, and occlusion break surge.[7-9] And now, dual pump systems give surgeons the flexibility of using venturi or peristaltic vacuum anytime within a case, on demand.[10] The following roundtable brings together thought leaders in cataract surgery to discuss these innovations and how best to use them in practice.

— Eric Donnenfeld, MD | Moderator

ACTIVE FLUIDICS: A GAME CHANGER IN CATARACT SURGERY

Eric Donnenfeld, MD: When I was a medical student, I told my pediatrician I wanted to be an ophthalmologist. He sent me to see his cousin, the great Dr. Charles Kelman, the father of phaco, who showed me my first cataract surgery. This was 40 years ago, and phaco was a disruptive technology. It is amazing how cataract surgery has changed over the last 50 years. When we first started, cataract extraction was a surgery predicated on using high amounts of energy to emulsify the lens.[11] Today, fluidics have changed the way we do the procedure, improving both safety and efficacy.[3,12]

Q | Dr. Dewey, how have fluidics changed over the course of your career?

Steven Dewey, MD: It's been pretty dramatic. The obvious thing is actually having fluidics. The first Kelman machines had a 100-mmHg vacuum, which really doesn't hold or allow you to manipulate the fragment; it allows you to remove some debris from the anterior chamber that you form with emulsification. As vacuum and monitoring of aspiration has improved, we've also gotten to the double-edged sword of things like post-occlusion surge, which causes chamber shallowing and has the potential for iris or capsule damage.[6,13,14] So, for me, some of the biggest revolutions have occurred with something as simple as occlusion mode where you actually start decreasing the vacuum intensity as you achieve an occlusion.[15] That, to me, was the most dramatic change. Before, we were trying to anticipate what was going to happen when that fragment finally gave way at the end of the needle and what was going to happen to the chamber. Whereas now, just watching the fragment disappear at the end of the needle without chamber fluctuation is quite remarkable.

Dr. Donnenfeld: I agree. Phaco was a blunt instrument when we first started where we hit the lens as hard as we could to break it up. Nowadays, in comparison, we use very little ultrasound energy. My goal is to use no energy at all; I use the femtosecond laser to prechop the lens and then follow that up with phaco employing mostly fluidics to remove the lens.

Q | When we use less energy and more fluidics, how does that impact safety and patient healing?

Subba R. Gollamudi, MD: I refer to early phaco machines as intraocular jackhammers. The bits of the nucleus would fly everywhere, and the actual energy dispersion caused tremendous collateral damage. With improved fluidics, we have much better control of ultrasound energy direction. We can reduce or eliminate ultrasound energy dispersion in the eye allowing for less trauma to the iris, capsule, and corneal endothelium.[3,5] In order to improve upon on current phaco techniques, we must prevent inflammation. Inflammation is the bane of our existence postoperatively. It causes problems at all the levels of the eye, from the cornea, to the retina, to the macula.[16]

Wendell Scott, MD: To me, what's really made a difference is the software that helps prevent the postocclusion surge with the peristaltic pumps. It helps regulate that outflow, which has created more chamber stability.[17] In the beginning, we were reacting to what was happening and trying to anticipate, but now algorithms and forced infusion are helping do that for us. We're really benefitting from advances in technology.

Marco Tavolato, MD: I've always been obsessed with the idea of reducing the amount of ultrasound used during cataract surgery. To achieve this goal, you have to act with fluidics, increasing infusion, vacuum, and flow. In these conditions you can hold the cataract and use a chopper to divide the lens. The problem is that, in such extreme conditions, the probability of collapse of the anterior chamber or severe turbulence within the eye is very high. The modern phaco machines use software, forced infusion systems, and tubing with increased stiffness to control the chamber stability and allow the surgeon to perform cataract surgery with a low level of ultrasound in safe conditions.

UNDERSTANDING PERISTALTIC AND VENTURI PUMPS

Dr. Donnenfeld: During the past 15 years, I have been an extraordinary advocate of using peristaltic and venturi pumps to improve my phaco technique and improve the safety and efficacy of the procedure.

Q | Dr. Dewey, how do these pumps work? How are they different?

Dr. Dewey: Peristaltic and venturi pumps do the same thing; they both drive fluid from one point to another. The difference is in how the vacuum regulates that movement of fluid. Peristaltic pumps are flow based. It creates flow and vacuum through rollers to achieve a continuous milking action.[10,18,19] The aspiration rate you set as part of the pump is the ultimate driver. The vacuum only occurs once an occlusion starts. Now, vacuum is just another side of aspiration, another side of flow, and it is the force behind the movement of fluid. Flow is a measurement of volume—it's how much fluid goes from this point to that point in a set amount of time. But vacuum is the force that drives that movement of fluid.

With a peristaltic pump, once the flow is interrupted, the pump responds by increasing the vacuum, which allows the fluid to restore to its normal flow. This interruption in flow is created by a nuclear fragment, and allows the vacuum to build to higher levels. By having these increased levels of vacuum available, you get great hold against the nucleus, and you're able to transfer the power more effectively—you use less power. In femtosecond laser-assisted cataract surgery (FLACS) cases or other softer cataracts, sometimes you can use no power.

With venturi systems, the vacuum drives the movement of fluid.[10,18,19] If your vacuum is set at 300 mmHg, it's going to be 300 mmHg whether or not there's an occlusion present. Comparing it to a peristaltic system, it's as if aspiration and vacuum are occurring simultaneously. It's going to then pull that fragment onto the tip with a consistent effort and force—there is no building of the force of vacuum with the occlusion, as the vacuum is constant.

It's this separation of aspiration and vacuum—the separation of flow and force that allows peristaltic vacuum to be fine-tuned based upon things that occur during nuclear removal (ie, the occlusion that decreases the flow). Flow in venturi vacuum has to be harnessed using physical means, such as decreasing the diameter of the phaco needle or tubing.

Dr. Donnenfeld: I've always liked venturi because the nucleus comes to me. With peristaltic, you have to go and occlude the tip. The problem with venturi is, because you have constant vacuum, you lose chamber stability. Venturi pumps almost always have lower vacuum levels than peristaltic pumps.

Q | How can you increase the fluidics of a venturi pump to achieve higher vacuums?

Dr. Gollamudi: Peristaltic is easier to imagine because we've learned about peristalsis in our gastrointestinal system in medical school. Peristaltic pumps function similarly; you see the little rollers on the side of the phaco machine that are rolling the tubing to push fluid through. It's a lower amount of flow, and you really don't fill things up until you get occlusion. In a peristaltic machine, you can protect against that postocclusion surge by using sensors that cut off at a certain point of vacuum in that tubing.

Venturi is harder to understand. I picture myself in a shower with a flappy shower curtain. You get the water flowing out of the faucet down into the drain, and that creates a venturi-type system that pulls the curtain into the tub, sticking against your leg and annoying you. It's the same physics principle of the venturi pump; the flow of water through the drain is pulling regardless of if there's occlusion at the drain or not. You get too much flow and that shower curtain is always coming against your leg and sticking. To prevent that, you can narrow the drain opening and lower the rate of fluid flowing from the faucet or the showerhead down the drain. Using FLACS technology, you can decrease the resistance with prefragmented nuclear fragments. This is a layman's way of describing the different options. But I think the biggest advances came in our ability to use computer technology—both hardware and software—to immediately sense where you are in this flow and create a feedback to increase or decrease the venturi rate.

Dr. Donnenfeld: There is little consensus in the literature on the 'best' pump style for cataract surgery. Cahoon et al found that that venturi pumps make cataract surgery more efficient and decreases chatter compared with peristaltic pumps.[10] Hida et al conducted a prospective, randomized, comparative study between the venturi and peristaltic pumps within the Whitestar system (Johnson & Johnson Vision), concluding that the venturi pump minimized fluid use, case time, and energy, but that both pump configurations were safe when used by an experienced surgeon. Hida et al did note that surgeons must adjust parameters according to their preference, technique, and skill level.[18]

Q | In your experiences, in what scenarios are peristaltic pumps advantageous?

Dr. Scott: For people who like to sculpt, a solid lens is probably a place for peristaltic. During the surgical learning process, we can control peristaltic in a way that persons starting out, like a resident, can hold the piece that they want and then apply the additional vacuum and let that build. For me personally, I prefer venturi because I am the one who is accelerating and decelerating; I'm not depending on occlusion and vacuum build. I like being in control of it. On the other hand, a person who is earlier in their career may feel safer allowing the vacuum to only build when they have occlusion.

Dr. Donnenfeld: I also prefer venturi, but there are two situations when I'll use peristaltic. Peristaltic will build higher vacuum than venturi. When I want to have the most adhesion of the lens nucleus to the tip of my phaco, I like to use peristaltic. For example, when I'm doing a 4-quadrant splitting technique, I want to have maximum hold on that lens nucleus while I'm extracting that first quadrant. Once I get the first quadrant, the others tend to follow. I'll also use peristaltic when I'm chopping because I want to make sure the nucleus doesn't shift.

Dr. Dewey: The number of times I use peristaltic vacuum is decreasing significantly. I prefer venturi across the board now, even in scenarios I used peristaltic before. Peristaltic oscillates. My peristaltic vacuum is typically set considerably higher than my venturi vacuum. But, any number of times, I don't achieve my maximum peristaltic vacuum because I'm continuously breaking occlusion during the emulsification. The vacuum never gets to that higher hold. The balance may tilt toward peristaltic in the denser lenses, otherwise venturi is more efficient.

Q | **DR. DONNENFELD:** Dr. Dewey, you told us you like venturi for most of your cases. Tell us when you believe venturi is most advantageous in your cataract surgery technique?

Dr. Dewey: I think venturi is most beneficial for cases where I need that chamber to be rock stable and want the fragments to come to me—post pars plana vitrectomy cases, small pupils, pseudoexfoliation, intraoperative floppy iris syndrome (IFIS). Followability in venturi is great, and that is the key to that technology. When someone is just starting out with venturi vacuum, the easiest thing is to have a dual pump system that allows you to switch from peristaltic to venturi vacuum at the end of the case to remove viscoelastic. I watched my number of pressure spikes drop considerably. The second step is just doing cortex. Venturi is active vacuum; you don't have to have an occlusion at the tip. Cortical removal is much more efficient with venturi. As you start becoming more comfortable with venturi and using it for sculpting and chopping, then you start getting to the more complex cases where you really must have a stable chamber. You don't want to see that iris or capsule bounce. That's where the steady state of venturi vacuum for me really comes in beautifully.

Dr. Tavolato: I started my surgical learning curve using a venturi pump, but today I routinely use both systems. During the past few years, all companies have developed software to make all stages of surgery more effective and increase patient safety. Today, there's not a big difference using a venturi or a peristaltic pump. The venturi pump is more predictable; every stage of the procedure is under control. The peristaltic pump has great holdability properties and achieves very high vacuum level. For these reasons, you must be very quick in all surgical stages, especially in cases of soft cataract. I'm convinced that in the future, all companies will have both pumps in all their machines.

Dr. Gollamudi: I like to park my phaco tip at the iris plane in the visual axis, as far away from other ocular tissues and surfaces as I can. Like Dr. Donnenfeld, I may grab that first quadrant with peristaltic, pull it up into that location as I just described, and then flip over to venturi, which allows all the fragments to come my way. There's no one-size-fits-all here. Some cases have different lens densities in which I may want to use peristaltic. That's one advantage the products on the market that allow us to transition between pumps. The WhiteStar Signature Pro Phacoemulsification System (Johnson & Johnson Vision) and the Zeiss Visalis 500 (Carl Zeiss Meditec) come with dual pump packs.[15,20] The new Veritas Vision System (Johnson & Johnson Vision) is a dual pump system.[21]

Dr. Donnenfeld: You just described exactly what I like to do, Dr. Gollamudi. I park my phaco tip in the middle of the pupil, equidistant from the posterior capsule, the corneal endothelium, and the iris. I call that the 'zone of safety.' I use my second hand to feed quadrants of the nucleus into the middle, and the venturi allows everything to come to the center more efficiently. It's great for small pupils and great for safety. This is the most efficient and safest way of doing cataract surgery. We're now able to double our venturi vacuum with the Veritas, which has forced infusion, allowing our vacuums to be dramatically higher, bringing the lens quadrants more efficiently to the phaco tip. The nucleus is almost magnetized to the phaco tip. It stays right where you want it, especially when you're using transverse phaco. Everything happens faster. It's more responsive and a better way of doing phaco.

RECENT INNOVATIONS IN PHACO SYSTEMS

Introducing the Veritas Vision System

Dr. Donnenfeld: Johnson & Johnson Vision recently introduced the Veritas Vision System to market. The Veritas is a next-generation phaco machine that features

several technologies that improve the safety and efficacy of cataract surgery.[22]

Q | Dr. Scott, tell us about the Veritas and what makes it special.

Dr. Scott: The Veritas provides more stability through Hybrid Fluidics Technology that minimizes postocclusion surge. Intelligent Occlusion Sensing Technologies automatically respond to occlusions to stabilize the chamber in dense cataract settings.[22] Pressurized infusion is the equivalent of adding 30 cc/min more of flow. The vacuum is pulling and the pressurized infusion is pushing; the combination improves efficiency and creates a circle of safety. The pressurized infusion stabilizes the tissue and allows you to use the maximum vacuum and the lowest phaco power. That's what is most impressive to me with the Veritas.

Dr. Dewey: Like Dr. Scott, I'm struck by the rock-solid chamber stability. The Veritas also has an advanced tubing system that really refines the outflow. Earlier I talked about harnessing venturi vacuum through physical means, and Dr. Gollamudi then described narrowing the shower drain. That's exactly what Johnson & Johnson did with the Veritas—they narrowed the lumen of the tubing. They also made the lining of the tubing stiffer, which means the compliance of the system is markedly reduced. The forces of the vacuum are now transmitted very precisely, and you can monitor the pressures much more effectively than you could with most recent tubing systems. With the Veritas, the vacuum levels are basically doubled, allowing me to run 500 mmHg venturi vacuum. The hold is magnetic and the followability is amazing. Adding transverse ultrasound to the efficiency of the venturi vacuum allows you to exploit that zone of safety.

Dr. Tavolato: Anterior chamber stability is the 'Holy Grail' in cataract surgery. The new tubing system, together with the pressured infusion, allow you to work in a stable chamber. The increased stiffness of the tube is the key factor in the efficiency of both peristaltic and venturi pumps. The venturi vacuum can be raised dramatically with total control of the procedure. Now it's really possible to switch from peristaltic to venturi during surgery according to the needs of the surgeon. With the previous machine, Johnson & Johnson's strength was ultrasound delivery with very sophisticated software. The Veritas furthers safety in all stages of surgery.

Dr. Donnenfeld: Although Alcon was the first to develop forced infusion 5 or 6 years ago, the Veritas from Johnson & Johnson is a leap-frogging technology. The followability and chamber stability is unparalleled, and I can now double my venturi vacuums with the forced infusion. The machine is doing all the work with fluidics; I very rarely use ultrasound. That translates to more patients achieving 20/20 vision the day after surgery. We can talk all we want about fluidics, physics, and the advantages of phaco machines, but happy patients with clear corneas are the end result we're looking for. The new technology we see today has made an enormous difference in achieving this goal. You only get one chance to make a good first impression on a patient having cataract surgery. The next day, patients come in with crisp, clear vision more often than before.

I like FLACS as well, and I think that the combination of femtosecond laser and venturi is a match made in heaven. The femtosecond laser chops the lens nucleus into small particles that will not occlude the phaco tip with peristaltic. They're too small, so they pass through without vacuum building. When you go to a venturi setting, these small particles follow very nicely. Venturi is good for removing viscoelastic without pressure spikes. It's also excellent for finding that occult piece of nuclear fragment hiding behind the iris that you wouldn't see with peristaltic. The venturi draws out that viscoelastic, that little piece of nucleus that you might have left in the eye and would see the next day.

Q | Dr. Scott, you do a lot of FLACS. What is your experience with it in your practice?

Dr. Scott: The biggest obstacle I've seen among surgeons transitioning to FLACS is that they try to use the same technique they've always used on a solid lens. But the FLACS lens is different; it's pre-fractured. The holdability with peristaltic is not as good. Therefore, if you try to use the technique for a solid lens on an FLACS lens, you're not going to be able to do it efficiently. Surgeons get frustrated with that. Part of being efficient with FLACS is transitioning to venturi. That's the biggest advantage of the dual pump system; it helps the peristaltic surgeon make a gradual transition to venturi. You start by learning how the venturi works. You are in control of the 'gas pedal' (ie, vacuum), and you learn how to use that efficiently. You can learn on the cortical cleanup first. The second step is moving away from sculpting and switching to venturi for removal of the nucleus.

Dr. Donnenfeld: If you do FLACS, a venturi pump is an absolute necessity because all the mechanical advantages of FLACS are lost when you go to peristaltic. The peristaltic just doesn't have enough of a nucleus hold to achieve the vacuum levels to allow fluidics to do the work. In 2021, all of the phaco systems are great. I find that the technologies continue to leapfrog, and someone develops an innovation every 3 or 4 years. Cataract surgery has evolved wonderfully.

Handpieces

Dr. Donnenfeld: In addition to the phaco machines themselves, handpieces have also evolved.

Q | Dr. Gollamudi, what are your thoughts on next-generation handpieces?

Dr. Gollamudi: Each generation of handpiece is able to generate more ultrasound energy and more focused, directed

energy. Ergonomically, they're more comfortable in our hands. For example, the newest Veritas comes with an option for a swivel handpiece.[21] Throughout our careers, we've learned to twist our fingers, wrists, and elbows when we're manipulating the phaco handpiece. But the Veritas swivel handpiece contains that movement to your wrists and fingertips to manipulate the direction of that phaco tip. Handpieces are not one-size-fits-all, but we're at a point where they are more tailored to our needs.

Dr. Tavolato: During my limited-market release experience, I used the new Veritas swivel handpiece. We perform a lot of cataract surgery every day, so our body position during surgery is important. Although we are always worried about our neck due to the microscope, our hands stay in a constricted position during surgery. The Veritas swivel handpiece is light. Rotating the distal part of the handpiece allows you to find the most ergonomic position during cataract surgery. With the curved tip, it's easy to catch every single fragment by only twisting our finger. The swivel handpiece is the beginning of a new era.

Ancillary technologies and tips

Dr. Dewey: The miLOOP (Carl Zeiss Meditec), a microinterventional lens fragmentation device designed to remove of hard cataracts, is a wonderful innovation. The miLOOP was approved by the US Food and Drug Administration in 2017, and its benefits have been confirmed in the literature. Ianchulev et al found that miLOOP reduced phaco energy by up to 53% in hard cataracts and lowered the surgical irrigation fluid volume used per case by up to 30%.[23]

The great thing about the miLOOP is you can use it at any point in time during the case. I use it to engage a very dense cataract or in patients who can't fit under the femtosecond laser. I also use it when I need to perform a nuclear cleaving because of some endothelial compromise. The miLOOP does a wonderful job cleaving. I don't use it frequently, but it is a wonderful tool when I need it.

Dr. Donnenfeld: I agree. In patients with hard nuclei, the miLOOP makes a world of difference in being able to get past the leathery posterior plate and chop the lens in half.

The Zepto (Centricity Vision) is an interesting technology. If you don't have femtosecond laser, it makes a perfectly round centered capsulotomy on the visual axis, which is actually stronger than a regular capsulotomy.[24] I like anything that automates the procedure and makes it more reproducible. The Zepto is a useful ancillary technology that easily performs beautiful capsulotomies when you don't have access to a femtosecond laser.

Dr. Gollamudi: In addition to different handpieces, we also have different gauge phaco tips with different bore sizes and angulation. I use the Dewey Radius Phaco Tip (MicroSurgical Technology), which was designed by Dr. Dewey.

Q | Dr. Dewey, can you talk a bit about your phaco tip design?

Dr. Dewey: The Dewey Radius Tip is completely rounded at the distal end so when you engage something other than nuclear material it's not meeting a sharp edge.[25,26] It's very effective at removing any density of nucleus. It's available in any configuration for any phaco machine. I use the Packard/Dewey version of my needle so that the outer gauge is actually a 22-gauge needle in diameter, but it has a 20-gauge inner lumen. The smaller outer diameter restricts irrigation less than a larger diameter, which improves chamber stability for a given size incision. This allows me to use a 2.2-mm incision

CHOPPING TECHNIQUES

Q | **DR. DONNENFELD:** Does anyone use chop as your primary phaco procedure?

Dr. Dewey: I primarily use a horizontal chop. It requires efficiency with regard to the vacuum. You must be able to impale the nucleus. The increased levels of vacuum we have currently allow you to bring the nucleus up on the tip of the needle as opposed to only pushing down. A well-performed horizontal chop is incredibly safe in terms of the zonules. And, more importantly, you're not spending a lot of power to create a trench.[27]

Dr. Tavolato: I'm also using horizontal chop in all cases. It can be a little tricky in soft cataracts because it's difficult to hold the nucleus. A correct hydrodelineation is mandatory in soft cases. This allows you to isolate the nucleus, and it's easier to remove. The venturi pump can be also helpful in soft cases because you don't need the occlusion.

Dr. Donnenfeld: I agree, the horizontal chop technique is wonderful. The key is having great holdability, which is difficult with lower vacuums.

Q | Are there advantages to the new phaco systems that have higher vacuum levels that allow you to chop more efficiently?

Dr. Dewey: I recently had the chance to participate in a trial of the Veritas, and the holdability and chamber stability really resonated with me. I normally use 300 mmHg venturi vacuum and was able to increase that to 500 mmHg with the Advanced Tubing, and 550 mmHg with the Advanced Tubing and Advanced Infusion. The increased vacuum was immediately evident. Placing the phaco tip bevel on the nucleus, I was able pull the nucleus up with the increased vacuum and engage power to 'lollipop' the nucleus onto the tip to stabilize it for the chop. Of course, you can get a decent hold at lower vacuum levels. The difference was wonderful with the increased useful vacuum of the Veritas.

Dr. Scott: My technique is to split the lens down the middle along the femto segmentation line. To do this, I use different techniques depending on the density of the cataract. For moderate nuclear sclerosis (NS), I use a technique I call endo-lenticular visco-dissection. Using a 30-gauge cannula on a Healon syringe (Johnson & Johnson Vision), I fill the anterior chamber and then direct the Healon into the central segmentation line, splitting the nucleus into two halves. That will work for moderately dense lenses. If it's too hard to get the cannula into that segment, then I drive the phaco needle into the center. Using the phaco tip as a fulcrum, I use my chopper (Scott Femto Chopper; Duckworth & Kent) to perform a quick chop maneuver. If the lens is rock hard, I perform what I call a horizontal compression chop. I take my chop instrument and put it distally, then I take a Bechert fork and place that temporally. Both instruments are drawn to the center. The horizonal opposing forces split the lens and do not place stress on the zonules. Other than the miLOOP, that's the only way I can get the rock-hard lenses apart. For laser cataract surgery, it's critical to split the lens in half and let the venturi do the rest.

Q | DR. DONNENFELD: How do you approach extraordinarily dense cataracts that are 4+ NS and brownish or blackish?

Dr. Scott: I saw two patients recently with these types of cataracts. One was like an advanced pseudoexfoliation case and the other was a patient with IFIS. You want to pay attention to pupil management, and you may need a ring. If you do, you'll need to put the ring in before doing the FLACS, if possible. We have our femtosecond lasers in the operating room. This allows us to use the laser as a tool in the operating room and not just as a pretreatment. I usually use trypan blue because if the lens is too hard to dimple down, I want to be 100% confident that the capsulotomy's perfect. These cases often have poor zonules, so you may want to be prepared to use capsule hooks.[28]

One of the advantages of FLACS is that you can make a large capsulotomy safely, much larger than you could do manually. I increase the diameter of the capsulotomy in dense cataract patients. If I can split the cataract into halves, then everything will be fine. If I can't, then I have to go up a bit in phaco power. I typically use a vacuum in a venturi mode of 600 mmHg and a phaco power of 1%. On these really dense lens, I occasionally have to go up to 20%.

Dr. Dewey: The miLOOP is very helpful to get through a dense, leathery plane. I agree with Dr. Scott on a larger capsulotomy, trypan blue, and using an iris retraction device before you get into the case; these things are critical. In the cases that are too dense to achieve the cleavage, I flip the nucleus using higher levels of vacuum as a manipulation tool. Typically, repeated impalings and failed chop attempts will result in a nearly segmented nucleus. I engage the distal rim of the bowl with higher levels of vacuum. I use my second instrument to depress the proximal area, and I can flip it, proximal rim down, and distal rim up. Or, I simply use the miLOOP and slide it around the equator to the posterior pole, and then close the miLOOP and section it into those magic two halves.

Dr. Gollamudi: In dense cataract cases, I'm generous with viscoelastic. I prefer dispersive viscoelastics to maintain protection of the other ocular surfaces, especially the endothelium. I wholeheartedly agree with a large capsulotomy. Sometimes I'll bring the lens up into the iris plane region and do a carousel technique where I don't cut the nucleus at all. It's an intact ball. I park my phaco tip facing inward toward the midperiphery and let the nucleus carousel itself into that phaco tip as it spins. That's something I've done on occasion.

Dr. Donnenfeld: I like to use the femtosecond laser on dense nuclei but instead of doing a waffle pattern where I'm dividing the lens up into small cubes, I will divide it into four quadrants. I increase the energy dramatically, which allows me to split the lens more efficiently. I also like to use the miLOOP and viscoelastic. I use Healon EndoCoat (Johnson & Johnson Vision), and I will overtly stop in the middle of the case and apply it a second time because sometimes the viscoelastic is dispersed due to the extra phaco time and vacuum. The biggest worry I have on dense nuclei is that there's almost never any cortex, and the nuclear fragments can cut the posterior capsules. Rather than hydro-dissect these cases, I visco-dissect them to create an artificial cortex with viscoelastic behind the lens to protect the posterior capsule. With the magic of the new phaco technologies and the ability to cut through these dense nuclei, problematic cases are dramatically more reasonable.

MANAGING DIFFICULT CASES

Intraoperative Floppy Iris Syndrome

Dr. Donnenfeld: IFIS remains a challenge for cataract surgeons and seems to strike at all times.[29]

Q | What are your pearls for managing IFIS in cataract surgery?

Dr. Gollamudi: In these patients, I have a very low threshold for using iris dilating, either with hooks or rings like the Malyugin ring (Microsurgical Technology).[29,30] These need to be used early on in the case. Beyond that, it's critical to minimize phaco power because that induces inflammation to release chemical mediators that will cause constriction of the pupil mid-case. There are some pharmacologic tools at our disposal to help with this. Surgeons can use phenylephrine and ketorolac intraocular solution 1%/0.3% (Omidria; Omeros) in their infusion bottles, for example, to maintain pupil diameter.

Dr. Scott: New pupil expanders like the I-Ring (BVI Medical) are also less traumatic to the iris.[31]

Dr. Dewey: I don't use pupil expanders often, but the Malyugin is my preference. If I can perform a viscodilation and get a reasonably sized capsulotomy, I can operate safely with a 3.5 to 4 mm pupil. Using venturi vacuum and keeping that tip right in the safe zone helps. With venturi followability, you're not chasing the fragments onto the anterior surface of the iris or losing them posterior to the iris.

Dr. Tavolato: Microincision cataract surgery is very helpful in these cases. I routinely perform a 2.2-mm incision, and I use a mixture of tropicamide, phenylephrine, and lidocaine intracameral solution (Mydrane; Thea Laboratories) that is available in Europe. In IFIS cases, I use this solution to stabilize the pupil. I don't use a pupil expander because inflammation in these cases is critical. I approach IFIS with a dispersive viscoelastic to induce viscomydriasis, then I perform the procedure in the center of the pupil (the safe zone) to avoid any pupil touch using the chop technique. If the pupil is going to constrict during cortical removal, I use an Osher hook in my left hand to push away the iris so the procedure can be done safely.

Dr. Donnenfeld: I like intracameral phenylephrine and ketorolac 1%/0.3% intraocular solution; that's been shown to be more effective for patients who have IFIS.[32] You want to be as efficient as possible in IFIS cases. That's where the new phaco devices are so effective; my phaco time has been reduced by 2 or 3 minutes. I also don't use many pupil expanding devices; if I can get my capsulorhexis in with 4 mm, I'm usually fine.

Q | To the group, when would you rather use a hook rather than a ring?

Dr. Gollamudi: Sometimes, especially in the cases with prior iritis, your pupil is bound down pretty small. You break the synechiae the best you can once you've entered the anterior chamber, but even the smallest iris dilation rings can be pretty traumatic when your pupil's bound down to 2 or 3 mm. I lean toward iris hooks in those cases.[33]

Dr. Donnenfeld: I agree. There are times where you have sector iridectomies, for example, where you can't get a ring in efficiently. That's another time to use a hook. I want to avoid hooks in general because I've found it makes IFIS worse. Rings are more efficient.[34]

CASE EXAMPLES: PEARLS FOR USING THE VERITAS SYSTEM ON A RANGE OF CATARACT DENSITIES

Dr. Dewey: Our first case is a 73-year-old Caucasian man with a 6-month history of decreasing vision in both eyes. He elected to have the 2+ NS cataract in his right eye staged with the Catalys Femtosecond Laser. This is the first day we are using the Veritas in the limited-market release. The followability is remarkable. The fragment does a hemicircle around the anterior chamber, but then it finds the lumen of the needle and it's immediately gone (Figure 1 A/B). I used 500 mmHg vacuum. Occlusion is not needed to see the vacuum build; the fragments build and disappear. There was, however, a river of fluid flowing out of my side port incision. To demonstrate the stability, I twisted the side port instrument to the left to remove the last bit. As I twisted my side port instrument to the side, fluid poured out of the side port. Despite that this is one of the worst side port incisions I've made in a while, the pressured infusion stabilized the anterior chamber.

Dr. Donnenfeld: Great case. What I was thinking about was how little movement you had of your phaco tip. Your

Figure 1. Removal of a 2+ nuclear sclerosis cataract using the Veritas Vision System. Utilizing advanced pressurized infusion, the chamber remains stable during removal of the final quadrant. The second instrument is deliberately kept away from the phaco needle and posterior capsule to demonstrate the chamber inflation. Although not easily identified, a stream of balanced salt solution is flowing along the shaft of the second instrument, dripping off of the bend. This demonstrates the utility of pressurized infusion at maintaining chamber depth even in the presence of leaky wounds (A). Without moving the phaco tip, the last quadrant fragmented, and the fragments flowed quickly into the lumen of the needle. The flow of irrigation fluid continued out of the side port incision. As the side port was an alternative point of high outflow, a small fragment is noted to have moved to that location. It was removed without difficulty with gentle manipulation. In the author's experience, with a properly constructed, nonleaking side port, the fragment would not have strayed from the normal flow generated by the higher levels of venturi vacuum (B).

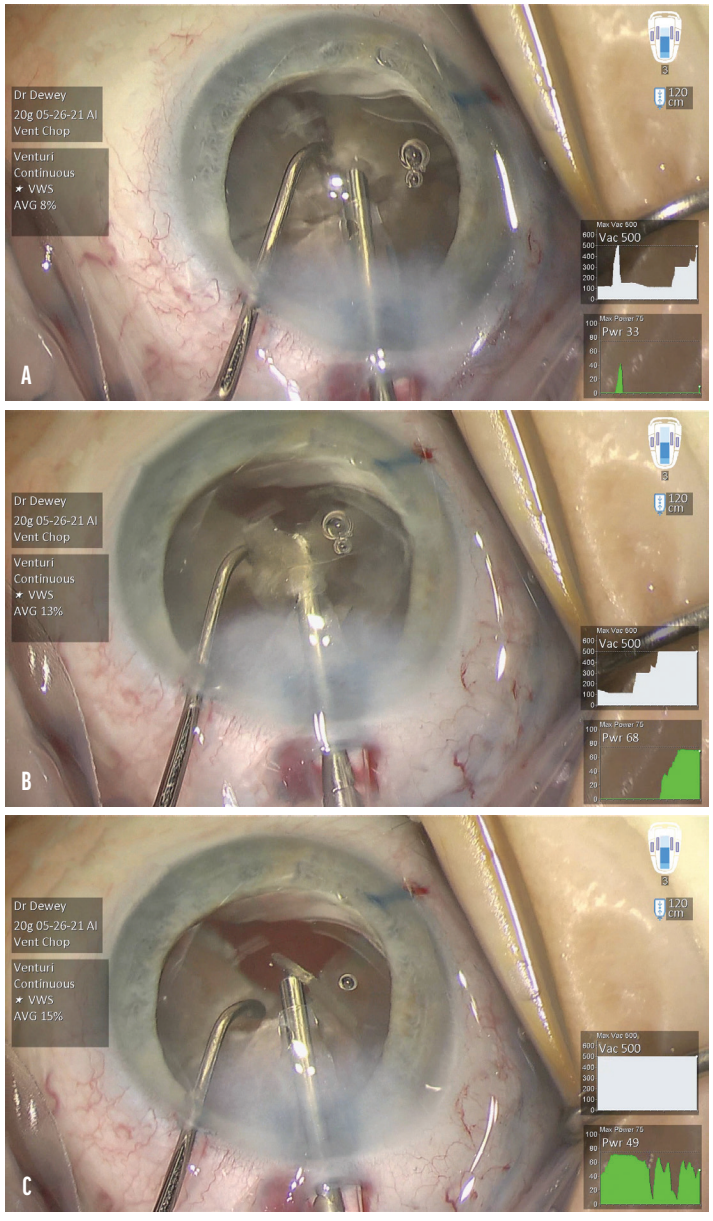

Figure 2. Removal of a 2+ NS cataract with the Veritas Vision System combined with femto. Once segmentation of the nucleus was performed, the first quadrant was free to mobilize (A). Application of power and vacuum quickly emulsified the quadrant without moving the phaco needle out of the safe zone. This sequence took about 12 seconds (B, C).

nondominant hand did all the work there. You held your phaco tip right in the middle of the eye, in the zone of safety, and you used your second instrument to bring the nuclear fragments to you with the venturi pulling right to the middle. This is an elegant display of venturi technology and surgical technique.

Dr. Dewey: Our next case focuses on the peristaltic pump with a very dense cataract. It belonged to a 72-year-old Caucasian woman who presented with a 3-year history of decreasing vision in her right eye. Her vision was hand motions, with a 4+ brunescent NS cataract and a diffuse posterior subcapsular opacity. I used trypan blue to stain the capsule and performed a very large capsulotomy. I used 500 mmHg vacuum and was fortunate to get a cleavage plane that I could propagate. It wasn't complete, so I repeated the chop. One of the beauties of a horizontal chop is if your chop fails, you've still weakened the body of the nucleus so there's less resistance on your second try. It's similar to a stop and chop. I rotated the lens and chopped again. Using high vacuum, I brought the first quadrant up to emulsify it. I depressed the foot pedal to engage power, and before I realized it, that first quadrant was gone. I was very pleased with the efficiency of the machine because this was still the first day of the limited-market release.

The Veritas performed exactly as desired. I used vacuum to lift the nucleus to me and power to impale. I tried to keep my needle in the center and use my chopper in my nondominant hand to manipulate the tissue. The material came to me. The transversal ultrasound is quite efficient at removing this material. At the end of 2 minutes and 56 seconds, the nucleus is gone.

Our final case uses femto, with the venturi vacuum dialed to 550 mmHg. The patient is a 76-year-old Caucasian man with a 2+ NS cataract electing to have his cataract surgery staged with the Catalys Femtosecond Laser. You see the classic femto sectioning of the nucleus and get that beautiful pneumodissection (Figure 2). The lens nucleus was mobile even before I put the needle in the eye. That was it—I was thrilled with how quickly it left the eye.

Dr. Donnenfeld: Terrific cases. Thank you to our faculty for their contributions. I've learned a tremendous amount about some of the new advances in phaco technology. In 2021, it's all about having the right technology, and we've discussed some great technology. ■

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INNOVATIONS IN PHACOEMULSIFICATION DEVICES AND TECHNIQUES IN 2021

Release Date: November 2021
Expiration Date: December 2022

INSTRUCTIONS FOR CREDIT

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DEMOGRAPHIC INFORMATION

Profession
___ MD/DO
___ OD
___ NP
___ Nurse/APN
___ PA
___ Other

Years in Practice
___ >20
___ 11-20
___ 6-10
___ 1-5
___ <1

Patients Seen Per Week (with the disease targeted in this activity)
___ 0
___ 1-15
___ 16-30
___ 31-50
___ >50

Region
___ Northeast
___ Northwest
___ Midwest
___ Southeast
___ Southwest

LEARNING OBJECTIVES

Did the program meet the following educational objectives?	**Agree**	**Neutral**	**Disagree**
Discuss the differences between peristaltic and venturi pumps including advantages, disadvantages, and safety and efficacy data	_____	_____	_____
Identify the benefits and challenges of recent innovation in phacoemulsification systems and techniques	_____	_____	_____
Assess phacoemulsification techniques and approaches and **apply** best practices for challenging cases to increase visual outcomes and patient satisfaction	_____	_____	_____

PLEASE COMPLETE AT THE CONCLUSION OF THE PROGRAM.

1. Based on this activity, please rate your confidence in your ability to describe innovations in phacoemulsification systems (based on a scale of 1 to 5, with 1 = "Not at all confident" and 5= "Very confident").

A. 1
B. 2
C. 3
D. 4
E. 5

2. What one innovation in phacoemulsification has had the greatest impact on the safety and efficacy of cataract surgery?

A. Active fluidics
B. Occlusion mode
C. Inflow regulating software
D. Aspiration monitoring

3. Which statement best describes the difference between peristaltic and venturi pumps?

A. Peristaltic pumps are flow based, venturi pumps are vacuum based
B. Peristaltic pumps are regulated by physical structures, venturi pumps are fine-tuned through circumstances within the surgery
C. Venturi pumps create flow through rollers, peristaltic pumps use vacuum to create flow
D. Venturi pumps have higher vacuum levels than peristaltic pumps

4. In what clinical situations is the venturi most advantageous? Select all that apply.

A. Dense lenses
B. Small pupils
C. Intraoperative floppy iris syndrome
D. During a 4-quadrant split

5. How is the Veritas Vision System different from other systems currently on the market?

A. The Veritas is the first system with forced infusion
B. The Veritas has active fluidics technology that monitors pressure in real time
C. The Veritas uses an advanced linear foot pedal to transition between peristaltic and venturi pumps
D. The Veritas is a dual pump system, allowing surgeons to switch between venturi and peristaltic pumps on demand

6. In what clinical situation is the Zepto useful?

A. The Zepto creates a perfectly round capsulotomy for surgeons without a femtosecond laser
B. The Zepto is designed to help chop extremely dense cataracts
C. The Zepto is a pupil-expanding device for poorly dilating or small pupils
D. The Zepto is useful for managing patients with floppy iris syndrome

7. What is the "zone of safety" for cataract surgery?

A. In the middle of the pupil
B. In the anterior chamber
C. Equidistant from the posterior capsule, iris, and corneal endothelium
D. In the posterior chamber

8. When managing an extremely dense cataract, what tool is always necessary to maximize success?

A. Trypan blue
B. miLOOP
C. Malyugin ring
D. Healon EndoCoat viscoelastic

9. According to the literature, which pump is the "best" for cataract surgery?

A. Peristaltic
B. Venturi
C. There is no "best" pump modality; it depends on the situation

ACTIVITY EVALUATION/SATISFACTION MEASURES

Your responses to the questions below will help us evaluate this CE/CME activity. They will provide us with evidence that improvements were made in patient care as a result of this activity.

Rate your knowledge/skill level prior to participating in this course: 5 = High, 1 = Low _____

Rate your knowledge/skill level after participating in this course: 5 = High, 1 = Low _____

This activity improved my competence in managing patients with this disease/condition/symptom _____ Yes _____ No

Probability of changing practice behavior based on this activity: _____ Yes _____ No _____No change needed

If you plan to change your practice behavior, what type of changes do you plan to implement? *(check all that apply)*

_____ Change in pharmaceutical therapy
_____ Change in diagnostic testing
_____ Change in current practice for referral
_____ My practice has been reinforced
_____ Change in nonpharmaceutical therapy
_____ Choice of treatment/management approach
_____ Change in differential diagnosis
_____ I do not plan to implement any new changes in practice

Please identify any barriers to change *(check all that apply)*:

_____ Cost
_____ Lack of consensus or professional guidelines
_____ Lack of administrative support
_____ Lack of experience
_____ Lack of time to assess/counsel patients
_____ Lack of opportunity (patients)
_____ Reimbursement/insurance issues
_____ Lack of resources (equipment)
_____ Patient compliance issues
_____ No barriers
_____ Other. Please specify: _____
_____

The design of the program was effective for the content conveyed. ___ Yes ___ No

The content supported the identified learning objectives. ___ Yes ___ No

The content was free of commercial bias. ___ Yes ___ No

The content was relative to your practice. ___ Yes ___ No

The faculty was effective. ___ Yes ___ No

You were satisfied overall with the activity. ___ Yes ___ No

Would you recommend this program to your colleagues? ___ Yes ___ No

Please check the Core Competencies (as defined by the Accreditation Council for Graduate Medical Education) that were enhanced through your participation in this activity:

_____ Patient Care
_____ Practice-Based Learning and Improvement
_____ Professionalism
_____ Medical Knowledge
_____ Interpersonal and Communication Skills
_____ System-Based Practice

Additional comments:

_____

_____ I certify that I have participated in this entire activity.

This information will help evaluate this activity; may we contact you by email in 3 months to ask if you have made changes to your practice based on this activity? If so, please provide your email address below.

_____