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High-Speed Cutting: Implications for Tractional Forces

Faster cut rates integrate with and complement other aspects of microinvasive vitrectomy surgery to reduce iatrogenic stress on the retina.

BY CARL D. REGILLO, MD

One of the key components of successful and safe retina surgery is the ability to engage target tissue while causing minimal or no disruption of adjacent tissue. Whether dissecting hyaloid near the retina, peeling a membrane, or performing core vitrectomy, the surgeon must be ever mindful of tractional forces and how much stress the intraocular maneuvers are placing on the retina-vitreous interface.

Several factors have been identified that affect tractional forces in retina surgery, including cutting speed and distance from the retina, aspiration rate, and duty cycle.[1] While the relative contribution of each is difficult to discern, it makes sense that controlling even one of those elements will reduce a stress on the retina that may induce iatrogenic breaks or other complications.

Cut rate is the most straightforward of these to understand. Because tractional forces increase or decrease in proportion to the rate at which vitreous is cut, a slower cut rate will impart greater tractional forces.[2] On the other hand, higher cut rates may result in less turbulence and traction on the retina.[3]

In light of this, the newly redesigned Alcon Advanced ULTRAVIT Vitrectomy Probe (Figure 1), which offers cutting speeds up to 10,000 cuts per minute (cpm), is a welcome addition to retina surgery. On its own, the higher cpm attainable with this instrument is impressive; yet, this upgrade has been coupled with additional engineering modifications that make the new probe a versatile and important addition to any surgeon's tool kit.

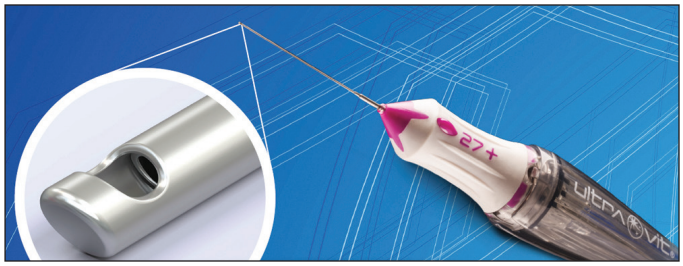


Figure 1. The new probe offers cutting speeds up to 10,000 cpm.

BENEFITS OF HIGH-SPEED CUTTING

The suggestion that high-speed cutting helps reduce traction makes intuitive sense, as a slower moving cutter will naturally grasp and cleave larger sections of vitreous with each cut compared with a faster moving cutter, thus yielding greater tension on the retina-vitreous interface. The negative consequences of this may be most important in the peripheral retina, where attachment points are already under greater tension and where the interface may be weaker. Indeed, the effect of slower cutting speeds is evident in studies looking at the association

AT A GLANCE

Key features of Alcon's Advanced ULTRAVIT Vitrectomy Probe include:

- Faster cutting rate: 10,000 cuts per minute
- Larger opening
- Bevel tip

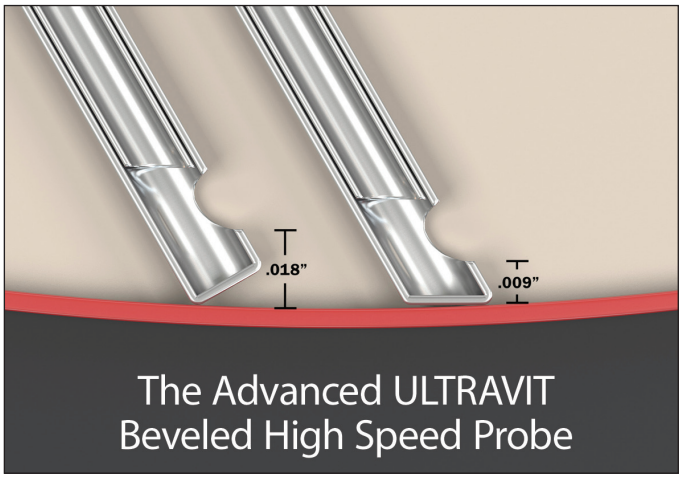


Figure 2. Advanced ULTRAVIT has also been designed with a bevel tip and a larger cutting port opening.

between cut speed and iatrogenic breaks. In a retrospective analysis, Rizzo et al noted a higher rate of peripheral breaks in surgeries where 2,500 cpm was used compared with surgeries where 5,000 cpm was used.[2] It follows that even greater benefit would be derived from use of higher speed cutting.

My own experience with the Advanced ULTRAVIT Vitrectomy Probe aligns with the findings from the literature noted above. In my hands, I found that the higher cut rate achieved the goal of better stability of tissue during cutting and yet did not detract from efficient vitreous removal. Even in cases of retinal detachment, where the risk of iatrogenic breaks is elevated, I was able to maintain excellent control of the vitreous with less undesirable movement of surrounding and adjacent retinal tissue.

ADDITIONAL DESIGN CONSIDERATIONS

One of my initial concerns with the Advanced Ultravit Vitrectomy Probe was that faster cut rate might sacrifice cutting efficiency. My thinking was that as cut rate increased, and because less tissue is cleaved with each pass, it would actually take more time to remove a volume of vitreous, especially as the gauge of the instrument got smaller. I am happy to say that these concerns were ultimately unfounded. In addition to faster cut speed, the Advanced ULTRAVIT has also been designed with a bevel tip and a larger cutting port opening (Figure 2), both features that complement the higher cutting speed while helping to maintain efficiency of the cutting action.

The beveled tip design of the Advanced ULTRAVIT Vitrectomy Probe is a seemingly minor addition, but it is in fact an important upgrade that facilitates greater control during delicate surgical maneuvers. The distance from the bottom of the cutter opening to the tip is the same as previous generations, but because of the beveling, the surgeon is working at an angle that moves the cutter port opening closer to the surface of the retina. According to the technical specifications, with the rounded end of previous generation vitrectomy probes, the cutting port stood about 0.018 inches from the retina; with the bevel design on the Advanced ULTRAVIT, the cutting port is about 0.009 inches from the retina.

The key benefit of the bevel design is the greater ability to access tissue planes around the globe. Where I have found this most useful is in situations where dissecting the vitreous close to the retina is advantageous, such as in both primary retinal detachment with mobile retina and those complicated by PVR. It is also a benefit in scenarios where I want to separate the hyaloid from the retinal surface and in dissecting fibrovascular tissue off the surface of the retina, such as in proliferative diabetic retinopathy.

Whereas the bevel design improves functionality and control, the larger cutter port opening is designed primarily to maintain efficiency of the cutting action. The larger opening also complements the higher cut rate in helping to control fluid dynamics while maintaining efficiency of vitreous cutting and removal. And, because the entire line of Advanced ULTRAVIT Vitrectomy Probe has been redesigned with larger cutter port openings, the advantage should be the same regardless of gauge. In fact, the positive benefit of a larger opening should be inversely proportion to the size of the gauge, such that users of 27+ will find the larger opening to be a tremendous asset for surgical efficiency.

PROBE FEATURES COMPLEMENT EXISTING TECHNOLOGY

Because the surgeon is cutting closer to the retina (due to the bevel tip) at a faster cut speed, two crucial components of induced tractional force are addressed when using the Advanced ULTRAVIT Vitrectomy Probe. These engineering improvements are complementary to other advancements that have already been integrated into the CONSTELLATION Vision System (Alcon) that help to reduce volatile surgical conditions. For instance, with the Constellation's on-board duty cycle control options, the surgeon can slow down cut rate to manage thick membranes and then increase cutting speed to perform more delicate maneuvers, all the while confident that duty cycle will automatically be maintained with no disruption of flow.

Duty cycle control, which allows the surgeon to modify the duty cycle independent of cutting and vacuum, is especially important when the concept of port-based flow limiting is considered. The term, first used by Steve Charles, MD, describes the phenomenon by which higher speed cutting combined with smaller gauge instruments increases fluidic resistance,

Refer to page 4 for Important Product Information.

leading to greater vitreous stability and reduced cutter chatter. This implies an advantage for smaller gauge surgery, but only if cutting speed can be optimized in proportion to duty cycle, which is the case when the ADVANCED ULTRAVIT Vitrectomy Probe is used with the CONSTELLATION platform.

It should be noted that these aspects of fluidic control are further enhanced by the ability to control aspiration using the foot pedal. In total, the relative contributions of high-speed cutting, duty cycle control, cutting action close to the retinal plane, and control over aspiration are complementary in establishing a surgical environment that is less prone to turbulence.

GETTING STARTED

When adopting new instruments for use in retina surgery, the question of what kinds of cases to test them in naturally arises. In the case of the Advanced ULTRAVIT Vitrectomy Probe, I do not really see a need to make that distinction. The probes are versatile enough for use in any surgical indication, and I plan to incorporate them fully into my surgical protocol once they become available.

The one thing I would say to colleagues trying these probes for the first time is that the advantages of the Advanced ULTRAVIT are best appreciated in more complicated cases. Higher cutting speed, and thus increased stability, is especially beneficial during delicate procedures, such as in traction retinal attachment in an eye with diabetic retinopathy. That said, there is certainly no disadvantage to using these probes in routine cases, either. There is no to minimal learning curve involved in their use, and so they can be easily integrated into one's regular routine.

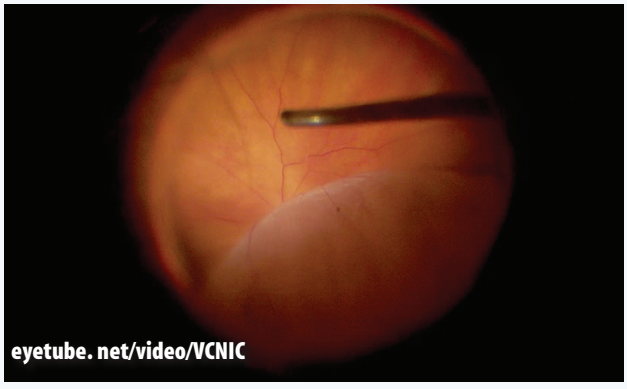
Surgeons who adopt the Advanced ULTRAVIT will find that it has been engineered with the same consideration for ergonomics as the current line of Ultravit probes. I noticed almost no difference in the feel of the probe in my hands compared with previous generations, and there was also no change in the amount of vibration.

The Advanced ULTRAVIT Vitrectomy Probe is a versatile instrument that should add to the ability to operate on any retina pathology, but there may be an additional aspect of versatility that is worth mentioning. I believe there is great utility in mixing gauges during surgery. I may start a case with 23-gauge instruments for vitreous removal, but when it comes time to operate on delicate tissue near the retina, I often switch to 25-gauge or even 27+. Overall, this practice follows from a belief that the various surgical instruments available for use can be used as specialty items if needed—sometimes more delicate work requires finer instrumentation, yet one can still take advantage of the greater efficiency inherent to larger port openings for the bulk of most procedures. Of course, mixing gauges is truly only possible with the use of valved trocars so that fluid egress can be minimized and IOP maintained.

Overall, there is no downside to using the same gauge throughout a case. Indeed, the faster cutting rate, larger opening, and bevel tip on the Advanced ULTRAVIT should give surgeons confidence that tractional forces are mitigated, regardless of gauge selection, especially when the probe is used in conjunction with the CONSTELLATION Vision System. Yet, it may also be the case that switching to a finer gauge in certain situations serves to further reduce stress on the retina. Personally, I am excited about what adding the 27+ Advanced ULTRAVIT Vitrectomy Probe may mean for my ability to dissect very delicate tissue planes without disrupting non-target tissue. The existing line of ULTRAVIT instruments were already well designed and versatile; the upgrades on the Advanced line only add to this.

WATCH IT NOW

Carl D. Regillo, MD, performs a 23-gauge vitrectomy using the Advanced ULTRAVIT 10,000 cpm vitrectomy probe with bevel tip.



1. Teixeira, et al. An experimental protocol of the model to quantify traction applied to the retina by vitreous cutters. *IOVS*. 2010;51(8):4181-4186.
2. Rizzo S, et al. Comparative study of the standard 25-gauge vitrectomy system and a new ultrahigh-speed 25-gauge system with duty cycle control in the treatment of various vitreoretinal diseases. *Retina*. 2011; 31:2007-2013.
3. Abulon DJ, et al. Porcine vitreous flow behavior during high-speed vitrectomy up to 7500 cuts per minute. Presented at Association for Research in Vision and Ophthalmology Annual Meeting. May 6 - 9, 2012; Fort Lauderdale, Florida.

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MIVS Important Product Information

Caution: Federal law restricts this device to sale by, or on the order of, a physician.

Indications for Use: The CONSTELLATION® Vision System is an ophthalmic microsurgical system that is indicated for both anterior segment (i.e., phacoemulsification and removal of cataracts) and posterior segment (i.e., vitreoretinal) ophthalmic surgery.

The ULTRAVIT® Vitrectomy Probe is indicated for vitreous cutting and aspiration, membrane cutting and aspiration, dissection of tissue and lens removal. The valved entry system is indicated for scleral incision, canulae for posterior instrument access and venting of valved cannulae. The infusion cannula is indicated for posterior segment infusion of liquid or gas.

Warnings and Precautions:
The infusion cannula is contraindicated for use of oil infusion.

- Attach only Alcon supplied products to console and cassette luer fittings. Improper usage or assembly could result in a potentially hazardous condition for the patient. Mismatch of surgical components and use of settings not specifically adjusted for a particular combination of surgical components may affect system performance and create a patient hazard. Do not connect surgical components to the patient's intravenous connections.
- Each surgical equipment/component combination may require specific surgical setting adjustments. Ensure that appropriate system settings are used with each product combination. Prior to initial use, contact your Alcon sales representative for in-service information.
- Care should be taken when inserting sharp instruments through the valve of the Valved Trocar Cannula. Cutting instrument such as vitreous cutters should not be actuated during insertion or removal to avoid cutting the valve membrane. Use the Valved Cannula Vent to vent fluids or gases as needed during injection of viscous oils or heavy liquids.
- Visually confirm that adequate air and liquid infusion flow occurs prior to attachment of infusion cannula to the eye.
- Ensure proper placement of trocar cannulas to prevent sub-retinal infusion.
- Leaking sclerotomies may lead to post operative hypotony.
- Vitreous traction has been known to create retinal tears and retinal detachments.
- Minimize light intensity and duration of exposure to the retina to reduce the risk of retinal photic injury.

ATTENTION: Please refer to the CONSTELLATION® Vision System Operators Manual for a complete listing of indications, warnings and precautions.