

High-Speed Vitrectomy in Practice

Ultrahigh-speed probes improve the surgical experience.

BY STANISLAO RIZZO, MD, AND TOMASO CAPOROSSO, MD

With the introduction of systems for microincisional vitrectomy surgery, vitreoretinal surgeons now have a large number of devices at their disposal to ensure safer and more effective surgery. Vitrectomy instrumentation is now available in a range of dimensions, including 23-, 25-, and 27-gauge systems, and there is a new generation of instruments capable of achieving cut rates of more than 5000 cuts per minute (cpm).

The ideal focus of vitrectomy surgery is to achieve the most complete removal of vitreous while minimizing complications and maximizing surgical outcomes. As has been the case with cataract surgery, technological advances have allowed the introduction of increasingly smaller caliber and more efficient instrumentation for vitreoretinal surgery. The ability to use vitreous cutting speeds of up to 7500 cpm has taken microincisional vitrectomy surgery to a new level. At the same time, the efficiency of small-caliber vitrectomy probes has improved, thus enhancing the safety and effectiveness of surgery of the vitreous base.

In the past few months, the current authors have had access to the Constellation Vision System with the Ultraviv high-speed vitrectomy probe (both by Alcon), capable of operating at 7500 cpm. During this time, we have used this system in complex cases such as retinal detachments and complications of proliferative diabetic retinopathy. As “test drivers” of this new instrumentation, we would like to share some of our impressions in this article.

Our experience to date includes more than 100 cases using the 7500 cpm probe. Based on our results and preliminary subjective impressions, we can state that this instrumentation helps to improve the efficiency and speed of vitreous removal in complex cases. These advantages are accompanied by greater safety as well: The number of iatrogenic tears in this series has been very low, even in cases with closely attached vitreous, such as posttraumatic retinal detachment in young patients, when the total removal of the vitreous gel plays a fundamental role in preventing secondary proliferative vitreoretinopathy (PVR).

This article describes the theoretical basis for this new ultrahigh-speed technology before we describe some of our clinical impressions of its use intraoperatively.

IMPACT OF CUT RATE ON FLOW RATE

No matter what instrumentation is used for vitreoretinal surgery, the final desired outcome continues to be the safe and effective removal of the vitreous body; for this reason, it is important to consider the dynamics of the vitreous flow rate through the vitrectomy probe. The performance of every vitrectomy instrument is related to the vitreous flow rate, which is determined by a combination of factors including cut rate, duty cycle, vacuum, and the inside diameter of the handpiece.

One of the most important features contributing to a vitrector's performance is its cut rate. Traditional teaching maintains that a high cut rate results in safer vitrectomy surgery. When the vitreous passes through the vitrectomy port and is cut, traction is transmitted to the retina through the attached collagen fibers. The amount of traction depends on the length of the aspirated collagen fibers and the working distance from the retina.

Quantifying the tractional force applied to the retina by vitreous cutters during pars plana vitrectomy has been a challenge. Teixeira et al performed a study in a porcine eye model to measure the tractional force applied to the retina by conventional pneumatic and electrical vitreous cutters during vitrectomy. They demonstrated that retinal traction, measured in dynes, increased with higher aspiration vacuum and proximity to the retina; conversely, retinal traction decreased with increasing cut rate.¹

Increasing the number of cuts per minute results in a smaller quantity of vitreous entering the port of the vitrector handpiece with each cut, therefore transmitting less traction to the retina and theoretically reducing the risk of iatrogenic tearing or movement of a detached retina.

The ability to increase the speed of vitreous cutting is the result of technological improvements in the movement of the blade at the mouth of the vitrectomy probe. Older-generation systems are driven electrically or via a

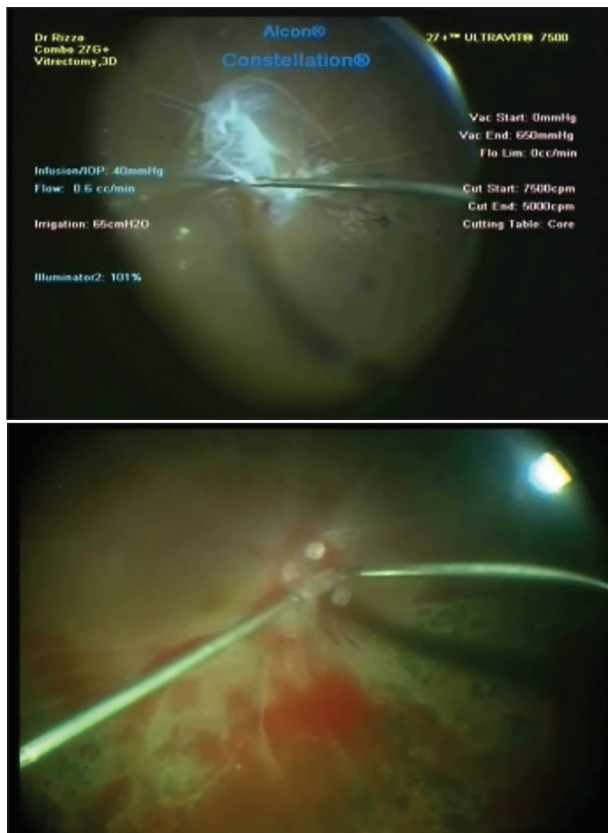


Figure. Images depicting the use of a 27-gauge cutter at 7500 cpm in tractional diabetic retinal detachment. The probe may be used as a spatula or scissors.

pneumatic spring. In the electric model, a motor is responsible for the return movement of the cutter. In the pneumatic spring model, by contrast, the movement of the guillotine is determined by a spring placed at the opposite side of the diaphragm. In new high-speed systems, a high number of cuts is attained with the use of a dual pneumatic system, in which the mechanical spring has been replaced by a second pneumatic drive pulse. By alternating pneumatic pulses on either side of the diaphragm, the cutter of the vitrectomy probe can open and close faster.

In addition to offering increased safety with less traction and retinal movement, faster cutting speeds have also improved efficiency by increasing the rate of vitreous flow through the cutter. The vitreous is a viscous substance, and cutting with the vitrector reduces its viscosity, in turn reducing the turbulence of the flow through the cutter and allowing for removal of a greater quantity of vitreous.

STUDY IN A PORCINE MODEL

In order to understand these key points regarding the dynamics of vitreous flow, it is necessary to refer to recent studies carried out on porcine vitreous, which is similar in

viscosity to human vitreous. In these studies, the authors measured the relationships between the vitreous flow, the diameter of the handpiece, and the number of cuts per minute.² These studies found that, proportionally, the smaller the diameter of the handpiece, the greater the increase in vitreous flow obtained by going from 5000 to 7500 cpm at equivalent programmed duty cycles.

Specifically, the authors found that, at 7500 cpm, the quantity of flow obtained at equivalent duty cycle was statistically greater with a 25-gauge handpiece compared with a larger-caliber 23-gauge handpiece. In addition, the increase in flow efficiency with the cut rate of 7500 cpm was observed with an even smaller-caliber 27-gauge handpiece. The reduction of vitreous viscosity induced by the higher number of cuts greatly increased the vitreous flow at equivalent duty cycle settings. The authors concluded that the aspiration of vitreous is therefore more efficient at 7500 cpm than at slower settings.²

CLINICAL EXPERIENCE

In our own surgical experience, the increase of vitreous cutter speed from 5000 to 7500 cpm has led to safer and more efficient removal of the vitreous base with a reduced risk of iatrogenic tearing. This is especially useful in situations such as a detached retina in which the retina is mobile. In surgery for a detached retina complicated by a giant retinal tear or by PVR, removal of a large amount of the vitreous base can be an impediment to obtaining the best surgical outcome possible on initial surgery and reducing the risk of further surgery. The reduction in retinal mobility made possible by the ultrahigh-speed cutter during the removal of the vitreous base has had a beneficial impact in these cases.

We performed a clinical study comparing the results of pars plana vitrectomy using a standard 25-gauge vitrectomy system and the new ultrahigh-speed 25-gauge system with duty cycle control (Alcon). With the ultrahigh-speed instrumentation, the duration of surgery was significantly shorter, and the frequency of intraoperative iatrogenic retinal breaks was lower.³

With macular surgery, the greater efficiency gained with 25- and 27-gauge handpieces due to the higher cut rate has improved the safety and speed of surgery. This type of surgery is increasingly becoming closer to cataract surgery in terms of precision and quality of results.

Use of the ultrahigh-speed system has left us with several clinical impressions. One notable feature is that the probe has a more acute sound than previous models, just as a higher-power car engine would. It is different not only from the duller sound of pneumatic spring vitrectomy systems, but also from Alcon's own 5000-cpm system.

A second intraoperative impression is that there is a decrease in the area "under the influence" of the probe—in

other words, a smaller area is affected by the vitrector. This was demonstrated in a study by Kirk Packo, MD, showing that the use of higher cut rates reduced distant vitreoretinal traction.⁴ The consequences of this effect can be seen as both positive and negative: On the 1 hand, we have a safer probe at our disposal, which acts only on the area of interest, and removal of vitreous takes place in a controlled manner; on the other, it is now necessary to search out areas of the vitreous to aspirate.

Thanks to the control of the duty cycle, use of the high cut rate does not reduce the flow through the cutter; at the same time, the flow rate of vitreous is increased due to the reduction in vitreous viscosity caused by the high-speed cutting.² This factor will be of great importance when the use of very small-caliber vitrectomy probes, such as 27 gauge, becomes more widespread.

Moreover, the use of 27-gauge probes with the ultrahigh speed of 7500 cpm has proved very useful in tractional retinal detachments: The probe can be employed as a small spatula or as scissors, allowing fewer exchanges of instruments and shortening the time of surgery (Figure).

CONCLUSION

Today's high-speed vitrectomy probes provide another set of instruments at our disposal for faster, more effective, and, above all, safer surgery. Faster cut rates appear to place less mechanical stress on the vitreous base, thus reducing the risk of iatrogenic tears. Laboratory studies have demonstrated that use of higher cutting speed results in less vitreous turbulence. Anecdotally, we have witnessed these effects in a series of complicated cases, in which high-speed cut rates improved the efficiency and speed of vitreous removal. ■

Stanislao Rizzo, MD, is director of U.O. Chirurgia Oftalmica, Ospedale Cisanello, Azienda Ospedaliero Universitaria Pisana in Pisa, Italy. He is a member of the Retina Today Editorial Board. He states that he has no financial interests relevant to the content of this article. Dr. Rizzo may be reached at stanislao.rizzo@gmail.com.



Tomaso Caporossi, MD, is a vitreoretinal surgeon at U.O. Chirurgia Oftalmica, Ospedale Cisanello, Azienda Ospedaliero Universitaria Pisana, in Pisa, Italy.

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