

Performance of a Modified Vitrectomy Probe in Small-gauge Vitrectomy

BY STANISLAO RIZZO, MD

Small-gauge sutureless pars plana vitrectomy reduces postoperative inflammation at the sclerotomy sites in comparison with conventional 20-gauge sutured pars plana vitrectomy, thus decreasing patient discomfort postoperatively and hastening recovery.¹⁻⁵ Despite the clinical advantages of smaller diameter vitrectomy systems, they pose significant challenges in vitreous removal as they decrease infusion and aspiration rates in comparison with 20-gauge systems. These factors may increase the time required for bulk vitreous removal, often counterbalancing the time saved in wound opening and closure.

In fact, the aspiration rate generated by the 25-gauge vitreous cutter is proportionally decreased because of its smaller port and diameter by a mean factor of 6.6² because, in accordance with Poiseuille law, the flow in a pipe (therefore the aspiration in a vitrectomy probe) is proportional to 4 times the radius of the tube.

To remedy part of this problem, we can use a higher aspiration (at least 600 mm of aspiration) or reduce the length of the cutter or the aspiration tubes or both. Also, increasing the port size of a vitreous cutter is an effective way to increase flow rates, as flow rapidly increases as the port diameter increases until it reaches a critical diameter. In fact, the flow begins to level off as the port diameter becomes larger than the inner lumen of the inner cutter. Beyond this diameter, the increase in port diameter appear to have less of an effect on overall flow rates.⁶

A vitrectomy probe, however, is not always open, as it

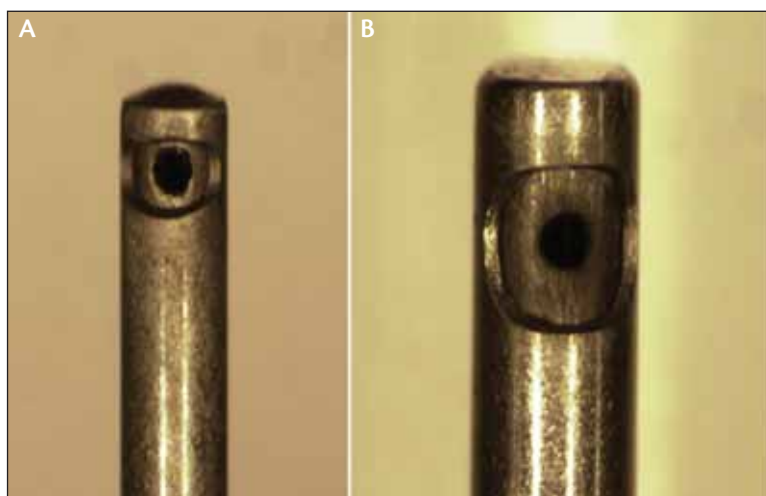


Figure 1. Alcon 23-gauge modified cutter (A). Bausch + Lomb 23-gauge modified cutter (B).

is equipped with a guillotine that opens and closes continuously. Duty cycle is the percentage of time the cutter port is open relative to the complete cutting cycle. Duty cycle has a significant influence on flow. We know, however, that in this era of high-speed vitrectomy, duty cycle diminishes in the new generations of cutters.⁷ A duty cycle of 50%, therefore, will always result in a time in which the cutter mouth will be closed, as will the optimization of duty cycle.

How does one solve the problem of the closure of the cutter? At our clinic in Pisa, Italy, our idea was to modify the cutter to include a “hole” in the internal guillotine blade that closes and opens in time. We made this modification on the vitrectomy probes for both the Stellaris PC (Bausch + Lomb, Aliso Viejo, CA) and the

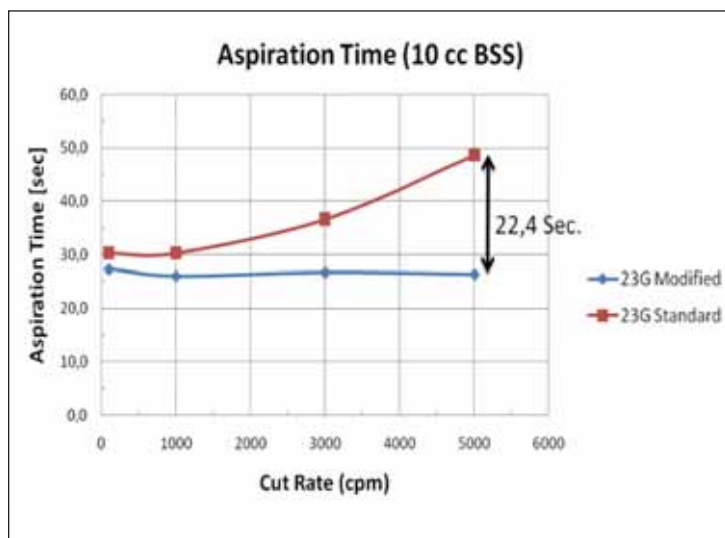


Figure 2. Alcon cutter: The time of aspiration remained constant even at very high cutting speeds, indicating almost no reduction of flow.

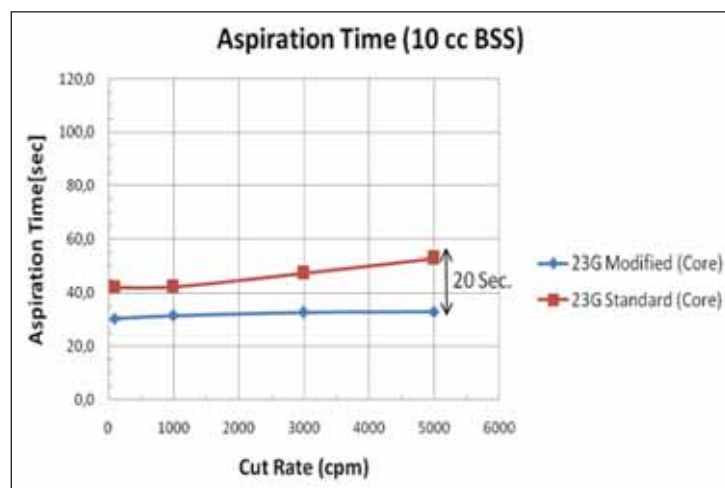


Figure 3. Bausch + Lomb cutter: Time of aspiration was significantly reduced with the modified cutter, demonstrating that spring-return cutters also benefit from the modification.

Constellation Vision System (Alcon Laboratories, Inc., Fort Worth, TX), 2 of the most widely used machines on the market. We chose to modify the 23-gauge cutters, as we use these more often than 25 gauge, but this modification can be made to all the gauges (Figure 1).

Our goal was to assess whether the change would lead to greater aspiration, a higher number of cuts, less traction on the retina, and/or an alteration of the resistance of the probes.

METHODS AND RESULTS

To assess flow rates, each cutter was suspended above a vial of water or porcine vitreous. An immediate

difference in flow was noted; with the standard cutter the flow was spasmodic and uncontrolled, while with the modified cutter the flow was smooth and continuous.

To compare the time of suction of 10 cc of both balanced salt solution and vitreous, we used 10 standard and 10 modified cutters at various cutting speeds from 100 cuts per minute (cpm) to 5000 cpm. The time for suction of 10 cc balanced salt solution with the currently available Alcon 23-gauge cutter increased; with the modified cutter, the time of aspiration remained constant even at very high cutting speeds, indicating almost no reduction of flow (45% less change in comparison with the standard cutter; Figure 2). We had similar findings with the Bausch + Lomb cutter. Time of aspiration was significantly reduced with the modified cutter, demonstrating that spring-return cutters also benefit from the modification (Figure 3).

The most interesting finding, however, was that the time of intake of 10 cc of porcine vitreous with the modified cutter was 35% less compared to the standard cutter (Figure 4).

It is well known that effects of aspiration, distance from the retina, and cut rate are crucial factors in the amount of retinal traction created by vitreous cutters, as retinal traction increases in proportion to rising aspiration vacuum and closer proximity to the retina. Conversely, retinal traction decreases with increasing cut rate.⁸ Therefore, increased flow can lead to more traction; however, the modifications to the guillotine blade allow more cuts per minute, minimizing the risk for traction.

To demonstrate this, we used a 0.5% hydrogel model to assess the efficiency of the modified probes. After vitrectomy with both the Alcon and Bausch + Lomb systems, samples were recovered and examined with an optical microscope. The fragments of hydrogel cut with modified probes were, on average, 50% smaller (Figure 5) than the fragments cut with the standard probes.

Finally, in order to demonstrate that modification of the probes does not alter the resistance, we ran the modified cutter uninterrupted for 2 hours at 5000 cpm, achieving 600 000 cuts. Upon examination with electron microscopy, the cutter showed no signs of wear or early cracking in the area surrounding the hole that was made in the internal guillotine blade (Figure 6).

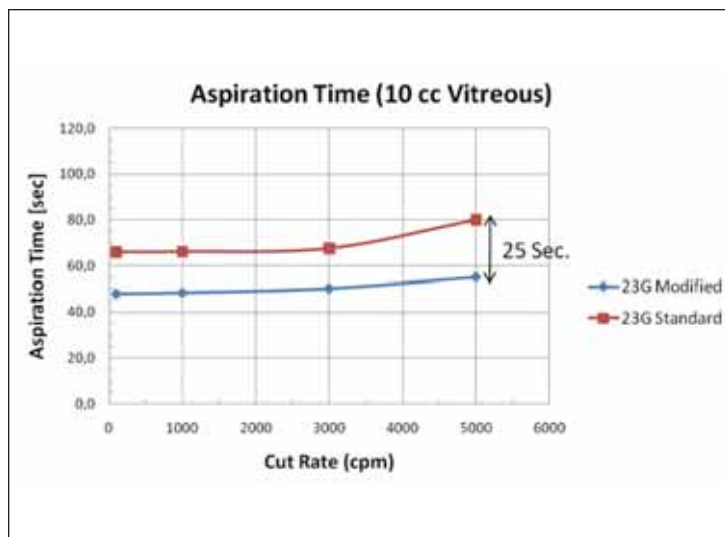


Figure 4. The time of intake of 10 cc of porcine vitreous with the modified cutter was 35% less compared with the standard cutter.

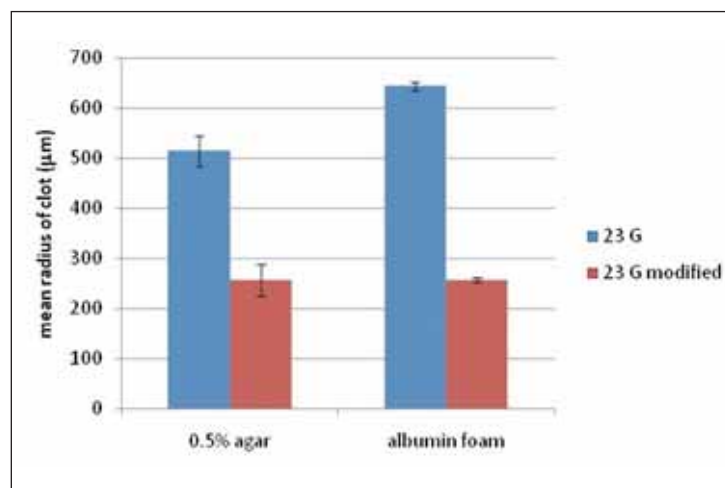


Figure 5. The fragments of hydrogel cut with modified probes were, on average, 50% smaller than the fragments cut with the standard probes.

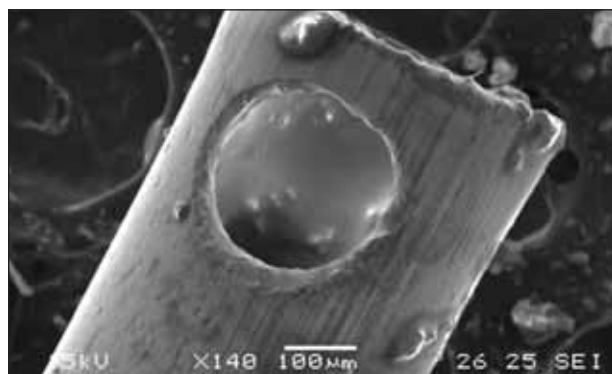


Figure 6. Upon examination with electron microscopy, the cutter showed no signs of wear or early cracking in the area surrounding the hole that was made in the internal guillotine blade.

SUMMARY

We have initiated a clinical trial to assess whether using this modified vitrectomy probe in a surgical setting translates to improved outcomes, and the results will be presented in the near future. This modification can be made to all available vitrectomy probes. Moreover, it is a simple and economical modification that requires no expensive or sophisticated technology, presenting the possibility that this approach may be another step forward in making small-gauge vitrectomy more effective, faster, and, most important, safer.

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Stanislao Rizzo MD, is Director of U.O. Chirurgia Oftalmica, Ospedale Cisanello, Azienda Ospedaliero Universitaria Pisana in Pisa, Italy. Dr. Rizzo is a member of the Retina Today Editorial Board. He can be reached at stanislao.rizzo@gmail.com.



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