

Wound Temperature and the Millennium

A review of wound temperature studies and clinical applications.

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Refinements in power modulations and control on the Millennium Microsurgical System (Bausch & Lomb, Rochester, NY) with the introduction of phacoburst technology (Bausch & Lomb) have reduced the total amount of ultrasonic energy delivered to the eye during phacoemulsification. These improvements lower the risk of thermal injury to the cornea and incision site. This article discusses the scope of the technological advantages offered by the new Millennium Microsurgical System's software.

PHACOBURST MODE

Phacoburst mode is ideal for phaco chop techniques because it decreases the cavitation energy around the phaco tip and thereby promotes less chatter, essentially creating more effective cutting and better followability (Figure 1). Newer power modulations with the addition of Custom Control Software (Bausch & Lomb) with microburst mode technology, hyperpulse technology, and variable duty cycle capabilities on the Millennium have led to refinements that further lower the total



Figure 1. The author demonstrates phaco parameters and vacuum levels using the phaco chop technique.

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ultrasonic energy delivery into the eye. Duty cycle is the duration or "on time" expressed as a percentage of the total cycle time.

PULSE MODE

The new expanded pulse mode allows the surgeon to program (1) linear power, (2) pulses per second (pps) between 0 to 120, and (3) a duty cycle between 10% and 90% of on time.

FIXED-BURST MODE

Fixed-burst mode also allows for linear power, and the surgeon directly programs the pulse duration (on time) and pulse interval (off time). Duration and interval choices are between 4 and 600 milliseconds.

MULTIPLE-BURST MODE

Multiple-burst mode utilizes fixed power, and the surgeon selects the pulse duration of between 4 and 600 milliseconds. The cycle time then varies, starting from 1,200 milliseconds at the beginning of foot pedal position three and becomes progressively shorter as the pedal is depressed.

When selecting a mode, it is helpful to remember that both pulse and fixed-burst modes allow the surgeon to design a particular pulse cycle pattern that is then locked in as the power is varied with the linear foot pedal. In contrast, multiple-burst mode locks in a particular ultrasonic power and then provides linear control of the interval or off time.

VACUUM CONTROL

The Millennium is unique in that it allows dual-linear control of vacuum levels, which gives the surgeon the ability to control and titrate the amount of vacuum used to remove a nuclear fragment while controlling the anterior chamber's stability. These two modalities (burst and dual-linear control) used in unison are ideal for phaco chop, because they create more effective cutting and better followability. A combination of refined power modulations and enhanced fluidic control aids in the performance of microincisional cataract surgery on any system.

FEASIBILITY STUDY

An initial feasibility in vitro study was performed on human cadaver eyes to measure the bare phaco needle's temperature within the clear corneal wound using different power modalities on the Millennium.¹ In pulse mode and a nonoccluded state at 100% power, the maximum temperature attained was 43.8° C. In the occluded state at 30% power, the maximum temperature was 51.7° C after 70 seconds of occlusion. For phaco-burst mode (multiple-burst modality) with a 160-millisecond burst-width interval, the maximum temperature was 41.4° C (nonoccluded at 100% power). At 80% power, the maximum temperature was 53.2° C within 60 seconds of full aspiration occlusion with the foot pedal completely depressed. For 80 milliseconds, burst width interval in both the nonoccluded and occluded states (100% power, foot pedal fully depressed for 3 minutes) showed no significant temperature rise. The maximum temperature was 33.6° C in the nonoccluded state and 41.8° C in the occluded state.

In all instances, the corneal wound remained clear. No wound burn or contracture was noted. The results revealed that bare-needle phacoemulsification did not result in clinically significant temperature rises in phacoburst mode using 80-millisecond burst-width intervals of up to 100% power and 160-millisecond burst-width intervals of up to 70% power. The demonstrated temperature rises were under clinically unusual parameters. Phacoemulsification with a sleeveless needle through a small stab incision can be safely performed using conventional phacoburst-mode settings within certain parameters on the Millennium.

ADDITIONAL RESEARCH

Other recent wound-temperature studies have focused on the newer power modulations, including hyperpulse and fixed burst. Settings of 8 pps with a 30% duty cycle; 120 pps with a 50% duty cycle; and fixed burst of 4 milliseconds on, 4 milliseconds off; 6 milliseconds on,

12 milliseconds off; and 6 milliseconds on, 24 milliseconds off, were all tested with a thermocoupler in the wound as described previously. There were no significant temperature rises.

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Investigators in a clinical study² used a quick-chop technique on cataracts that ranged from 2 to 4+ nuclear sclerosis. They performed phacoemulsification using a burst-mode setting of 100-millisecond burst-width intervals with a bare, sleeveless Microflow 300° bevel, 20-gauge phaco needle (Bausch & Lomb) through a 1.4-mm incision made with a diamond blade. This wound size allows the 1.1-mm phaco tip to enter the eye without any strain on the wound, and a small amount of egressing fluid cools the wound without compromising the chamber. The investigators also employed irrigation through a 1.4-mm sideport incision using a 19-gauge irrigating chopper with two side irrigating ports. Using an irrigating chopper with two side irrigating ports rather than one main central port may improve the fluidics within the anterior chamber (Figure 2), thus allowing currents to direct nuclear fragments to the phaco tip, whereas a direct stream of fluid could repel fragments.

In this study, vacuum levels were set on the Millennium using Venturi mode to vary between 165 and 325 mm Hg using Dual-Linear Technology, and the bottle height was set between 115 and 125 cm. The ability to vary the vacuum during bimanual phacoemulsification allows

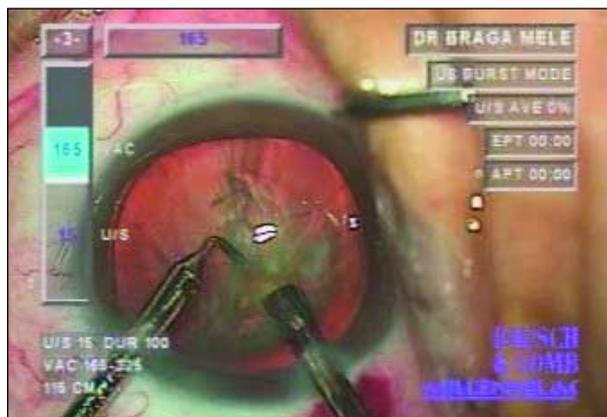


Figure 2. The author maneuvers a dual-port irrigating chopper through two 1.4-mm incisions.

the surgeon the control necessary to titrate the vacuum level according to the fluidics and thereby minimize anterior chamber instability. For instance, one could use high vacuum when the tip is fully occluded and hold is necessary in order to ensure an efficient chop technique. However, once occlusion is broken, the surgeon may lower the vacuum to a level that allows the efficient removal of the segment but also stabilizes the anterior chamber. Under the parameters and technique described earlier, phacoemulsification has been performed safely and effectively by means of a bimanual sleeveless method with no trauma or burns to the wounds. Absolute phaco times ranged from 2 to 4 seconds in these cases, and the average case time from skin to skin was approximately 2 minutes longer than with conventional phaco techniques. The wounds were clear on the first postoperative day with negligible corneal edema.

PERSONAL EXPERIENCE

In summary, bimanual microincisional phacoemulsification on the Millennium can be performed using multiple power modalities and can be refined to be surgeon-specific. I prefer to use a quick chop or flip technique and currently have modified my technique to use the new fixed-burst modality with a 4- or 6-millisecond duration of on time and a 4- or 12-millisecond duration of off time. My linear power ranges from 0 to 30%, and my linear vacuum varies from 165 to 325 mm Hg using Dual-Linear Technology.

The Millennium gives the surgeon the ability to access and control flow, vacuum, and ultrasound power simultaneously and to the degree that is necessary. It is the ability to deliver short bursts of phaco power and utilize vacuum as an extractive technique—ultimately decreasing the thermal energy delivery to the eye and speeding visual recovery—that facilitates the use of sleeveless microincisional cataract surgery. ■

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1. Braga-Mele R, Lui E. Feasibility of sleeveless bimanual phacoemulsification on the Millennium Microsurgical System. *J Cataract Refract Surg.* 2003;29:2199-2203.
2. Braga-Mele R. Bimanual sleeveless phaco on the Millennium: wound temperature and clinical studies. Paper presented at: The ASCRS/ASOA Symposium on Cataract, IOL, and Refractive Surgery; April 15, 2003; San Francisco, CA.