OPTIMIZING ENERGY EFFICIENCY IN PHACOEMULSIFICATION

Techniques and considerations.

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Little is more consistent in life than debate. In medicine, and in ophthalmology in particular, the efficacy of various therapies is a subject of endless discussion. Topics range from niche, novel therapies to the staple surgical procedure of our specialty—phacoemulsification.

Few would argue against the benefits of energy efficiency. When applied to phacoemulsification, the term *efficiency* refers to the careful management and utilization of ultrasound energy to minimize tissue damage and optimize surgical outcomes. The debate over energy efficiency in this context generally centers on the extent and effects of the energy delivered to the eye, endothelial function, and surgical outcomes.[1-3] Depending on the platform used, energy delivery can be reported as cumulative dissipated energy (CDE) or effective phaco time. This article uses CDE.

Many factors can affect CDE, including surgeon experience, ocular and medical comorbidities, cataract disassembly method, and cataract density.[1] Studies of CDE's impact on patients' BCVA and endothelial function have shown mixed results.[1-3] Despite this, cataract surgeons seek to minimize the amount of energy delivered during surgery by refining techniques and utilizing advanced technologies. The goal is to achieve more precise cataract extraction while minimizing the potential effects of CDE on surrounding tissues.

ENERGY, EFFICIENCY, AND EFFECTS

Phaco needles are optimized to move within a frequency range that is most efficient for nuclear emulsification. The most common frequency is 40 kHz. Changes in phaco power do not alter the frequency but rather the stroke length of the probe. Lens emulsification is accomplished by the physical impact of the tip via a process called *cavitation*. When the needle moves at high speed, it pulls dissolved gases out of the aqueous solution to create microbubbles and subsequent implosion, delivering intense heat and shock waves to the lens.

Many mechanisms for phaco-induced damage have been proposed. Some studies have shown a positive correlation between CDE levels and endothelial cell loss, possibly through thermal or transmitted shock wave injury to the endothelium.[1-3] Likewise, the effects of high cavitation and chatter can damage surrounding ocular structures.[4] Regardless of the mechanism, forward-thinking ophthalmologists seek to minimize energy delivery into the eye while maximizing energy efficiency.

HOW TO OPTIMIZE EFFICIENCY

The Preoperative Evaluation

Reducing CDE begins with the preoperative evaluation. A careful assessment of the patient empowers the ophthalmologist to determine the safest and most efficient surgical approach. Understanding a patient's unique risk profile facilitates safer, more effective surgery. Advanced age, cataract density, and diabetes have all been shown to affect CDE levels.[1,5,6]

Regular Maintenance and Equipment

The latest phaco machines have been designed to optimize

energy delivery. For example, a steep bevel creates more holding force with higher cutting efficiency and can decrease energy use. Disadvantages of a steep bevel, however, such as difficulty achieving occlusion and full vacuum, require consideration. Regular maintenance helps equipment function optimally, and a properly calibrated machine also improves energy efficiency.

Optimized Power Modulation

Adjusting phaco settings and taking a thoughtful approach to each case can help reduce energy delivery during the procedure. The three primary power delivery modalities include continuous, pulsed, and burst. For both continuous and pulse mode, the power delivery is a linear relationship with the depression of the footpedal. Pulse mode uses alternating periods of off-and-on ultrasound energy delivery, resulting in less energy's being delivered compared to continuous mode. Burst mode delivers a preset maximum power during each release of energy; as the footpedal is depressed, the interval between bursts decreases, eventually becoming continuous if fully depressed. Further energy modulation is possible by adjusting the duty cycle, representing the ratio of phaco-on time to total time.

Traditional phacoemulsification uses longitudinal energy delivery through a forward-and-backward movement. Some machines incorporate a horizontal component into ultrasound energy delivery. Torsional ultrasound uses a side-to-side motion, whereas transversal ultrasound is delivered in an elliptical fashion, combining the longitudinal and horizontal elements into one motion pattern. Depending on the technique, either longitudinal or horizontal ultrasound energy can improve the overall efficiency of the phaco steps (see *General Principles of Phaco Energy*).

GENERAL PRINCIPLES OF PHACO ENERGY

- **No. 1:** Linear or variable ultrasound allows surgeons to titrate energy delivery over a fixed or panel ultrasound setting. This varies depending on the surgical step and technique.
- **No. 2:** Torsional power is generally sufficient for soft lenses but may increase tip occlusion compared to longitudinal ultrasound. With Intelligent Phaco software (Alcon), a short burst of longitudinal ultrasound energy is delivered when the tip becomes occluded during the use of torsional ultrasound.
- **No. 3:** During the use of longitudinal ultrasound, chatter can increase as nuclear pieces are pushed away from the tip.
- **No. 4:** Burst mode helps facilitate chopping by improving surgeon control of the depth of entry into the nucleus.
- **No. 5:** Both pulse and continuous mode are well suited for sculpting and are frequently employed during quadrant removal. Pulse mode decreases energy use and may reduce chatter as a fragment is aspirated to the tip during off time.

Choosing the Best Surgical Technique

Details of the patient's anatomy and pathology are noted during the preoperative evaluation. If endothelial dysfunction is detected, minimizing energy use, protecting the endothelium with a soft-shell OVD technique, and employing low-flow settings are advisable. Although divide and conquer is generally safer for novice surgeons and may be beneficial in eyes with dense lenses, a phaco chop technique could reduce the duration of surgery and amount of ultrasound energy, thereby increasing efficiency.[7,8] In eyes with dense cataracts, manual small-incision cataract surgery should be considered to avoid the need for high amounts of ultrasound energy.

CONCLUSION

The impact of phaco energy efficiency on surgical outcomes remains debatable, but high CDE levels can affect surrounding tissue. Generally, the best surgical technique is the one that is safest in the ophthalmologist's hands for each unique patient. A surgeon's periodic reevaluation of their approach to phacoemulsification can help them deliver the best outcomes to their patients. ■

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