# Advances In Phacoemulcification

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Recent advances in phacoemulsification technology are geared towards fulfilling the needs of newer techniques like bimanual phaco i.e. decreasing phaco energy dissipation, preventing surge etc

The recent advances may be classified under the following headings

**1. Reduction in phaco energy dissipation.**

- *Modification of phaco power duration*
  - *Burst mode*
  - *Ocuburst mode*
  - *Ocupulse mode*
  - *White star technology*
- *Phaco tips covered with non conducting materials i.e. Teflon coated tips*
- *Sonic phaco*
- *Oscillating tips / AdvanTec Legacy with NeoSonix (Alcon).*
- *Phacotmesis*
- *High-speed rotary-impeller technology (Avantix)*

**2. Suppression of surge.**

- *Increasing inflow*
  - *Air Pump*
  - *Forced Infusion(Accurus)*
- *Decreasing outflow*
  - *Cruise Control Device*
  - *Newer tips with smaller bore and outflow constriction*
- *Surge modulation*
  - *Microprocessor Controlled Fluidics*
  - *Optikon ACS3 surge suppression device*
  - *Aspiration Bypass Stabilizer (ABS) Microtip (Alcon)*
- *Dual Linear Footswitch*

**3. Higher and controlled vaccum.**

- *Newer pumps*
  - *B &L Concentrix Pump*
  - *Allergen Sovereign Digital Pulse Pump*
- *Newer high vacuum tips*

**4. Replacing the moving phaco tip.**

- *Aqualase*
- *Pulsatome*
- *Laser phacoemulsification*
  - Dodick photolysis
  - Paradigm Photon Ocular Surgery System
  - Aesculap-Meditec Phacolase
  - Wavelight Laser Technlogie Adagio phaco laser system
  - Premier Laser Systems Centuri

**5. To aid in capsulorhexis.**

- *Fugo/Plasma Blade for capsulorhexis*
- *Newer micro capsulorhexis forceps*

**6. To prevent posterior capsular rents.**

- *Flexible (Silicone) I/A Tips*

**1. Reduction in phaco energy dissipation.**

**Modification of phaco power duration.**

Modification of phaco power duration by means of the various burst and pulse modes allow the phaco tip to cool down in between the periods of high energy dissipation. This helps in preventing corneal burns as the temperature of the phaco tip is less as compared to continuous mode.

- **Burst mode**

Burst of 100% U/S energy for 90 milliseconds followed by preset U/S levels of pulse or continuous energy.

- **OcuBurst mode**

During tip occlusion, Linear Pulsed U/S Power changes to Bursts of 100% energy which persist for 100 milliseconds .Between the bursts there is 100 milliseconds of rest time.

- **OcuPulse mode**

Continuous phaco changes to Pulse phaco automatically when tip is occluded.

**Whitestar technology (Allergan Sovereign)**

With the Whitestar Technology in the new Sovereign it is not only possible for the surgeon to set the duration of pulse/burst mode but also the duration of rest time in between pulse/burst mode (POWER MATRIX

Phaco). Micropulses can also be utilized in which phaco energy is delivered for extremely short duration followed by a longer rest interval . The pulses of ultrasound energy, measured to 1/100 of a millisecond, are faster than the thermal relaxation time of the tissue, so there is no heating. The popular analogy is the difference between an incandescent and a fluorescent lightbulb. The fluorescent lightbulb alternates rapidly between on and off. Thus it remains cool, with little energy loss in the form of heat and much more efficient illumination.


**Phaco tips covered with non conducting materials.**

Crozafon described the use of Teflon-coated phaco tips for bimanual high-frequency pulsed phaco, and suggested that these tips would reduce friction and therefore allow surgery with a sleeveless needle (Crozafon P. The use of minimal stress and the Teflon-coated tip for bimanual, high-frequency pulsed phacoemulsification, presented at the 14th meeting of the Japanese Society of Cataract and Refractive Surgery, Kyoto, Japan, July 1999).

**Sonic phaco (STAAR SonicWave)**

Most phacoemulsification machines have the phaco tips vibrating at 35,000 to 45,000 cycles per second (Hz). Such high speeds are necessary to overcome the inertia of the nucleus. However such high speeds produce a lot of heat. With Sonic WAVE™ technology both low frequency (Sonic) pulses and normal ultrasonic pulses are incorporated in the same machine so as to decrease U/S energy usage.

- The Sonic WAVE™ blends low frequency pulses (40-400 Hz) with new ultra vacuum technology to produce a cataract removal system more efficient than ultrasound.
- Sonic Wave™ technology brings cataract and refractive surgeons a reduced energy, “fragmentation” tool, utilizing 200 to 1000 times less energy than ultrasound.
- No thermal burns, No sleeve, No change in technique, No loss of efficiency, No heat, No cavitation, No ultrasonic wave turbulence.

**Oscillating tips / AdvanTec Legacy with NeoSonix (Alcon).**

The AdvanTec Legacy with NeoSonix combines the ultrasonic vibratory motion of the tip with a sonic oscillatory motion. This oscillation is programmable for power level in foot position 3, starting time, and percentage of 2 degrees of oscillation.

When sculpting, this oscillation tends to prevent occlusion, which thus reduces the threat to the posterior capsule. It also automatically repositions material at the tip as the surgeon evacuates nuclear material after chopping or cracking the nucleus. As a result, the tip doesn't become embedded, cavitating but not moving material down.

In addition to the NeoSonix vibrations, new AdvanTec software provides more stable fluidics and more exact digital monitoring of phaco power. Program sequencing allows the surgeon to use the foot pedal to change from one program to another, with an option for linear flow or vacuum in foot position 2.

**Phacotmesis**

Phacotmesis, is a new technique which combines mechanical rotary energy with ultrasound for aggressive removal of lens material.

During initial reaserch into phacoemulsification by Dr. Charles Kelman rotary burrs were tried to emulsify the nucleus but there were problems associated with nucleus stability. However a new approach (Phacotmesis) is being tried in which rotational energy is combined with conventional U/S energy to decrease the total energy requirement.

**High-speed rotary-impeller /Avantix (Optex Ophthalmics, licensed by Bausch & Lomb).**

Avantix (formerly known as Catarex) uses heat-free, high-speed rotary-impeller technology to remove cataracts. It allows surgeons to evacuate both the nucleus and the cortex, without a special aspiration

step. It creates a vortex of motion within the capsular bag that expands the bag and draws material through the tip. The rotary impellor emulsifies the material and draws it out of the eye. It is done with a 1-mm capsulorhexis, with a cannula slightly larger to confine the action to the capsule.

This will enable us to inject a flexible injectable polymer that will refill the capsular bag and allow for not only good vision, but accommodation as well.

**2. Suppression of surge.**

**Air Pump / Forced Infusion (Alcon Accurus)**

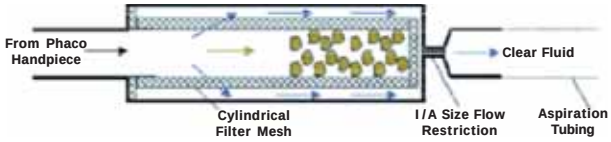

**Forced infusion through the irrigating chopper created with the Accurus surgical system**

The purpose of this pump is to push more fluid into the eye. The air is generated by a pump, and this pushes air into the bottle of intraocular solution

1. It actively pushes fluid into the eye.
2. The amount of fluid can be controlled independent of the bottle height.
3. The increase of fluid prevents surge and its consequences.
4. The continuous maintenance of the anterior chamber allows the surgeon to freely manipulate the instruments and tissues inside the eye.

5. The positive pressure creates a tense zonule and so a firm capsular bag and it facilitates the chop maneuvers.
6. The endothelium is pushed forward while the posterior capsule is pushed back.
7. The continuous irrigation through the phaco tip incision cools continuously the tip and the cornea, avoiding thermal burns.

**Cruise Control Device**




Cruise Control is a device developed by STAAR as a filter between the phaco handpiece and aspiration tubing that captures nuclear material, enhances the safety and efficiency of phaco procedures by eliminating surges and stabilizing the anterior chamber. Cruise Control eliminates vacuum surge regardless of the size and configuration of phaco tips or tubing even with lower bottle height.

**Newer tips with smaller bore and outflow constriction**

Newer micro tips of 500-600 micron size decrease the amount of fluid being aspirated from the anterior chamber. This increases the safety margin while using higher vacuum and decreases the likely hood of surge. Normal sized tips (19/20 G) with an outflow constriction at the neck also decrease the fluid outflow but are more likely to get blocked by lens particles. The downside of using these tips is that they increase the effective phaco time.

**Microprocessor Controlled Fluidics (Sovereign)**

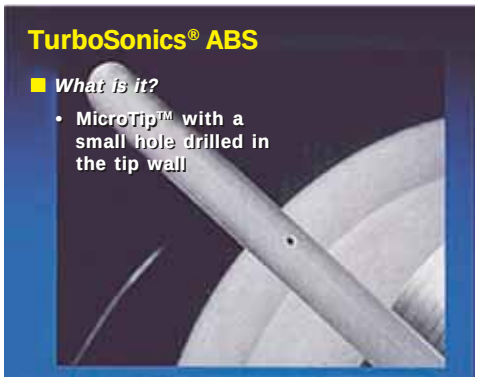
Microprocessors sample vacuum and flow parameters 50 times a second, creating a "virtual" anterior chamber model. At the moment of surge, the machine computer senses the increase in flow and instantaneously slows or reverses the pump to stop surge production.

**Optikon ACS3 surge suppression device**

**ACS3 surge suppression device**

It is connected in between the infusion bottle tubing and the irrigating sleeve . The diaphragm of the ASC3 device acts like a balloon and holds reserve irrigating fluid which is utilized in case of a surge.

**Aspiration Bypass Stabilizer (ABS) Microtip (Alcon)**




Alcon Legacy-The aspiration bypass system (ABS) tips have 0.175 mm holes drilled in the shaft of the needle. During occlusion, the hole provides for a continuous alternate fluid flow. This will cause dampening of the surge on occlusion break.

**Dual Linear Footswitch**

The dual linear foot pedal can be programmed to separate both the flow and vacuum from power. In this way, flow or vacuum can be lowered before beginning the emulsification of an occluding fragment. The emulsification therefore occurs in the presence of a lower vacuum or flow so that surge is minimized.

**3. Higher and controlled vaccum.**

**Hybrid Pumps**

The primary example of the hybrid pumps are the Allergan Sovereign peristaltic pump or the Bausch & Lomb Concentrix pump. These pumps are interesting in that they are able to act like either a vacuum or flow pump dependent upon programming. They are the most recent supplement to pump types and are generally controlled by digital inputs, creating incredible flexibility and responsiveness.

The challenge to the surgeon is to balance the effect of phaco intensity, which tends to push nuclear fragments off the phaco tip with the effect of flow, which attracts fragments toward the phaco tip and vacuum, holding the fragments on the phaco tip. Generally, low flow slows down intraocular events, while high flow speeds them up. Low or zero vacuum is helpful during sculpting of a hard or large nucleus, where the high power intensity of the tip may be applied near the iris or anterior capsule. Zero vacuum will avoid inadvertent aspiration of the iris or capsule, preventing significant morbidity.

The Allergan peristaltic pump. Controlled by digital inputs it can move forward, backward, or oscillate, instantaneously.

The Bausch & Lomb Concentrix pump. Inside two cam-shaped discs rotate to generate a vacuum that is regulated to emulate either a peristaltic or venturi pump.

**Newer high vacuum tips**

(Newer tips with smaller bore and outflow constriction have been discussed earlier)

**4. Replacing the moving phaco tip.**

**Aqualase (Alcon).**

This is a waterjet-based instrument that uses rapid pulses of warmed balanced salt solution to perform phacolysis. It erodes, disassembles and emulsifies lens material and may dissolve some of it as well. The surgeon can program pulse frequency, pulse force and energy duration. The warming of the lens material may also destroy the lens epithelial cells and reduce the likelihood of capsule opacification.

**Pulsatome (Visijet Inc. and Ponte Nossa Acquisition Corp.).**

This uses a lower pressure, pulsed waterjet for the fragmentation, irrigation, hydrodissection and aspiration of cataracts. The Pulsatome hand piece goes through a 2.9-mm incision, and it uses short pulses of 20 mL of BSS under a pressure of 1,000 psi to break the nucleus into smaller fragments that are aspirated through the aspiration port on the hand piece.The advantages of this system are its potentially high safety

profile, no wound heat and easy learning curve

**Laser phacoemulsification**

**Dodick Photolysis (Arc Laser)**

**Dodick Laser Photolysis Probe: A lightweight disposable probe made of injection molded plastic**

The Dodick Photolysis system, being developed by the Arc Laser Corp., of Salt Lake City, uses a pulsed Nd:YAG laser beam directed toward a titanium target inside a probe to create indirect shock waves that disrupt the lens.

The procedure involves using two 1.2-mm diameter probes - one delivers infusion and one delivers lasing action and aspiration at the tip, in a bimanual technique through two 1.4-mm incisions.

**Paradigm Photon Ocular Surgery System**

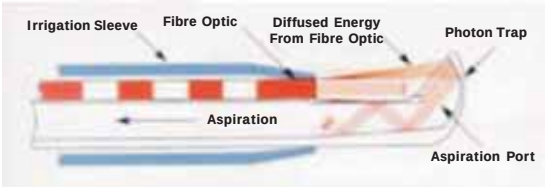



**Diagram of Paradigm Photon Trap photofragmentation chamber.**

**Paradigm Photon laser tip**

Paradigm Medical Industries, of Salt Lake City, is developing an Nd:YAG laser called the Photon, which it will incorporate into its Precisionist Thirty thousand ultrasonic phaco system.

According to the company, more than 6,000 cases have been performed worldwide. In the United States, Paradigm completed Phase I clinical trials in 1997, and received FDA approval to proceed to Phase II clinical trials to provide the statistical data required for final approval of the system. In May, Paradigm received the CE mark permitting the sale of the Photon laser in Europe and renewed a strategic alliance with Pharmacia to help distribute this technology. Full 510(k) approval is expected shortly, according to Paradigm.

One of the most unique elements of the system is that the irrigation, aspiration, and laser delivery all will come from one handpiece with a 1.8-mm tip. The laser is directly applied to the cataract, which is emulsified and removed through the I/A system. This technology is intended for use in cataracts up to 3+ hardness.

**Aesculap-Meditec Phacolase**

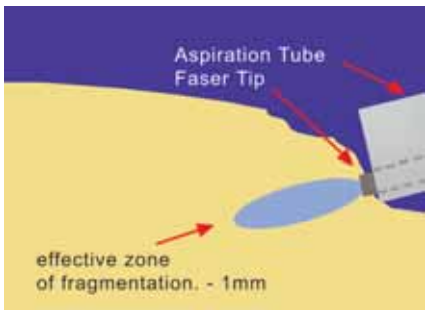



**Diagram of phacoemulsification cavitation bubble**

The Asclepion-Meditec (Jena, Germany) Phacolase system uses a different type of Er:YAG laser to directly emulsify the cataract. With a bimanual technique, one probe is used for irrigation while the other combines aspiration with the laser through incision sizes ranging between 1 and 1.3 mm.

**Wavelight Laser Technlogie Adagio phaco laser system**

WaveLight, of Erlangen, Germany,

is also developing an Er:YAG laser phaco system, called the Adagio. This system uses a tip between 1.2 and 1.7 mm and a bimanual I/A system to remove emulsified tissue. This technology has also received a CE mark and is available in Europe and other international locations, with U.S. clinical trials scheduled to begin shortly.

**Premier Laser Systems Centuri**

EyeSys-Premier, of Irvine, Calif., developed the Centauri Er:YAG laser phaco system and filed a marketing application with the FDA. This system uses a 0.6-mm diameter tip, which can make an incision as small as 0.7 mm. Premier filed for Chapter 11 bankruptcy in March, leaving the future of this technology up in the air.

**5. To aid in capsulorhexis.**

**Newer micro capsulorhexis forceps**

They are modified vitrectomy forceps which allows for surgeons less accustomed to needle caplsulorhexis to perform the procedure through a 20G incision.

**Fugo/Plasma Blade for capsulorhexis**

The Fugo Blade (invented by Richard J. Fugo, MD, a cataract surgeon in Norristown, Pa.) focuses electromagnetic energy to create a plasma blade capable of cutting biological tissue. The filament is thinner than a human hair, and thus can go through a tiny incision. The blade uses very low energy-the whole system runs on three small flashlight batteries. It also has an "electronic echo" function, electronic feedback that prompts it to turn itself off as it approach es the capsule during emulsification.

While the continuous curvilinear capsulorhexis remains the leading method for making a capsular opening, the "postage stamp capsulotomy," made with the Fugo blade, provides an up-and-coming alternative for anterior capsulotomies. A Fugo blade capsulotomy contains 60 to 80 small waves along the capsulotomy margin. These inward projections generate a stable capsule margin and reduce the chance of radial tears. The electromagnetic field of the blade automatically generates this type of margin.

**6. To prevent posterior capsular rents.**

**Flexible (Silicone) I/A Tips**

Lab tests on cadaver eyes have indicated that the silicone I/A tip is significantly more friendly to the capsule.Being capsule-friendly enables the surgeon to be less tentative in stripping cortex from the capsule, making this part of the procedure both quicker and safer.Using a metal I/A tip also makes capsule polishing a delicate manipulation at best. Studies indicate that better, quicker results can be achieved by placing the silicone I/A tip into the cortex with the aspiration port facing the cortex, rather than positioning it away from the cortex.

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