Optimizing your Pre-operative Measurements and Phacoemulsification Parameters for Cataract Surgery

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Bascom Palmer Eye Institute
Relevant Disclosures

- ALCON
- Allergan
- Johnson and Johnson
- Bausch and Lomb
- Omeros
- Lumenis
- Kala Pharmaceuticals
- Quidel
- SUN
- Takeda
- Zeiss
Preliminary Questions
What percentage of cataract surgery patients have signs of ocular surface disease?

A. Less than 5%
B. 10-20%
C. 20-30%
D. 30-40%
E. Greater than 50%
Which formula below can be most broadly applied to MOST eyes:

A. Holladay I  
B. Hoffer  
C. SRK/T  
D. Barrett  
E. Olsen
All of the following are screening tools for ocular surface disease before cataract surgery except:

A. Tear osmolarity
B. Pachymetry
C. Inflammadry (MMP9 assay)
D. Schirmer Test
E. Tear break up time
F. Questionaires (OSDI or SPEED)
Making our very best
Pre-operative Measurements
“I want perfection in my correction”
We may be creating monsters...
Benchmark Standards for Cataract Surgery

Outcome of routine cataract surgeries:
55% within 0.5 D of target
85% within 1D of target

How inaccurate are we?

**SRK II Formula**

\[ \text{IOL} = A - 0.9K - 2.5L \]

When we estimate the corneal power, there is almost one diopter error in IOL power for each diopter error in K value.

- IOL Power = implant power to produce emmetropia
- A = A constant
- K = average K reading in diopters
- L = Axial length
4 Main Sources of Error

1. Ocular surface disease
   • Affects both power and axis
2. Instrument Error
   • Inaccurate measurement of anterior corneal curvature by keratometers (post-keratorefractive surgery).
   • Assumption of a spherocylindrical cornea.
3. Formula Error
4. Index of Refraction (after LASIK/PRK)
Most Recent Formulas…

3\textsuperscript{rd} Generation Formulas
- Holladay
- Hoffer Q
- SRK/T

4\textsuperscript{th} Generation Formulas
- Holladay II
- Haigis with Clinical History Method

5\textsuperscript{th} Generation Formulas
- Olsen
- Barrett

**Wang-Koch Adjustment** - Axial length > 26
Used with several formulas to adapt for longer eyes
Optimized Optical Biometry AL = (0.8289 x measured AL) + 4.2663
Which formula do I use??
### Barrett Universal II Formula

#### Patient Data
- **Doctor Name**: [ ]
- **Patient Name**: [ ]
- **Patient ID**: [ ]

#### Lens Factor
- **OD**: (-2.0~5.0) or A Constant (112~125)
- **OS**: Personal Constant

#### Measurements:

<table>
<thead>
<tr>
<th>Measurements</th>
<th>OD</th>
<th>OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial Length</td>
<td>(F) (12~38 mm)</td>
<td>(L) (12~38 mm)</td>
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<tr>
<td>Measured K1</td>
<td>(F) (35~55 D)</td>
<td>(L) (35~55 D)</td>
</tr>
<tr>
<td>Measured K2</td>
<td>(F) (35~55 D)</td>
<td>(L) (35~55 D)</td>
</tr>
<tr>
<td>Optical ACD</td>
<td>(F) (0~6 mm)</td>
<td>(L) (0~6 mm)</td>
</tr>
<tr>
<td>Refraction</td>
<td>(F) (-10~10 D)</td>
<td>(L) o</td>
</tr>
</tbody>
</table>

#### Optional:
- **Lens Thickness**: (F) (2~8 mm) or (L) (2~8 mm)
- **WTW**: (F) (8~14 mm) or (L) (8~14 mm)

(Your data will not be saved. Please print a copy for your record.)

K INDEX: 1.3375 [ ] K INDEX: 1.332 [ ]
How do we get our very best numbers for these formulas?
How do we make our best measurements?
SCREENING FOR POTENTIAL COMPLICATIONS BEFORE SURGERY
#1 Reason for IOL Miscalculations is OSD

*Dry Eye is Ubiquitous!*

Dry Eye is very common
- 14-20% of population suffer from it
- 25% of visits in a general practice!

Dry Eye is complex
- Systemic and iatrogenic etiologies
- Worsened by our surgeries
- #1 most common cause of “failed surgery”

Dry Eye can be debilitating
- Frustration and doctor shopping is common
The International Dry Eye Workshop (DEWS)

2007

2007 Report of the International Dry Eye WorkShop (DEWS)


Management and Therapy Subcommittee members: Stephen C. Pflugfelder, MD (Chair); Gerd Geerling, MD; Shigeru Kinoshita, MD; Michael A. Lemp, MD; James McCulley, MD; Daniel Nelson, MD; Gary N. Novack, PhD; Jun Shimazaki, MD; Clive Wilson, PhD.

2017

TFOS DEWS II Management and Therapy Report

Lyndon Jones, FCOptom, PhD
d, Laura E. Downie, BOptom, PhD
d, Donald Korb, OD
d, Jose M. Benitez-del-Castillo, MD, PhD
d, Reza Dana, MD
d, Sophie X. Deng, MD, PhD
d, Pham N. Dong, MD
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d, Richard Yudi Hida, MD
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d, Joseph Tauber, MD
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d, Jianjiang Xu, MD, PhD
d, James S. Wolffsohn, FCOptom, PhD
d, Jennifer P. Craig, MCOptom, PhD
d
Dry Eyes in our Cataract Patients

The Prospective Health Assessment of Cataract Patients’ Ocular Surface (PHACO) study: the effect of dry eye

William B Trattler1 Parag A Majmudar2 Eric D Donnenfeld3 Marguerite B McDonald4 Karl G Stonecipher5 Damien F Goldberg6

On behalf of the PHACO Study Group

1Center for Excellence in Eye Care, Miami, FL, USA; 2Chicago Cornea Consultants, Chicago, IL, USA; 3Ophthalmic Consultants of Long Island, Garden City, NY, USA; 4Ophthalmic Consultants of Long Island, Lynbrook, NY, USA; 5University North Carolina School of Medicine, Chapel Hill, NC, USA; 6Wolstan & Goldberg Eye Associates, Torrance, CA, USA

Purpose: To determine the incidence and severity of dry eye as determined by the International Task Force (ITF) scale in patients being screened for cataract surgery.

Patients and methods: This was a prospective, multi-center, observational study of 136 patients, at least 55 years of age, who were scheduled to undergo cataract surgery. The primary outcome measure was the incidence of dry eye as evaluated by grade on the ITF scale and secondary outcome measures include tear break-up time (TBUT), ocular surface disease index score, corneal staining with fluorescein, conjunctival staining with lissamine green, and a patient questionnaire to evaluate symptoms of dry eye.

Results: Mean patient age was 70.7 years. A total of 73.5% of patients were Caucasian and 50% were female. Almost 60% had never complained of a foreign body sensation; only 13% complained of a foreign body sensation half or most of the time. The majority of patients (62.9%) had a TBUT ≤5 seconds, 77% of eyes had positive corneal staining and 50% of the eyes had positive central corneal staining. Eighteen percent had Schirmer’s score with anesthesia ≤5 mm.

Conclusion: The incidence of dry eye in patients scheduled to undergo cataract surgery in a real-world setting is higher than anticipated.

Keywords: cataract surgery screening, dry eye, International Task Force scale, observational study
Summary of Study
(Patients scheduled for cataract surgery)

One of five or 22.1% of these patients had a prior diagnosis of Ocular Surface Disease

- Patients are often **asymptomatic**
- Dry eye signs are very common in patients scheduled for cataract surgery
  - TBUT:
    - More than 60% with very abnormal TBUT (≤ 5 seconds)
  - Corneal Staining
    - 50% with Central staining
  - Schirmer’s score
    - 21.3% with very low Schirmer’s (≤5mm)
Prevalence of ocular surface dysfunction in patients presenting for cataract surgery evaluation

Preeya K. Gupta, MD, Owen J. Drinkwater, BS, BA, Keith W. VanDusen, BS, Ashley R. Brissette, MD, MSc, Christopher E. Starr, MD

57% with abnormal osmolarity
40% with corneal staining
Dysfunctional Tear Syndrome

Current Opinion In Ophthalmology; January 2017
Assessments Currently Used to Diagnose DTS

- Aqueous tear production
  - Schirmer tests (with and without anesthesia)
- Tear stability
  - Tear breakup time (TBUT)
- Ocular surface disease
  - Clinical examination
    - (tear lake, meibomian glands, lid function, etc)
- Dye staining
  - Fluorescein
  - Rose Bengal or Lissamine Green
- Presence of patient symptoms
You have to screen for surface disease
I try to ask patients how their eyes feel.
OSDI
Ocular Surface Disease Index

SPEED
Questionnaire
Identify other underlying high-risk diseases or medications?

- **Thorough medication history**
  - Antihistamines/Decongestants/Antidepressants
  - Eye drops – **GLAUCOMA!!!**

- **Systemic history**
  - Sjogren’s (Sjo test)
  - Rheumatoid
  - Rosacea
  - Thyroid dysfunction
  - Lupus
  - Hormonal changes
Slit-Lamp Examination

Evaluation of Tear Meniscus “Tear Lake”

Fluorescein Staining

Rose Bengal/ Lissamine Green Staining

Image sources: Mark Milner, Karl Stonecipher, American Academy of Ophthalmology purchased by Mark Milner
Conjunctival Staining-Pick One

Fluorescein

Lissamine Green
Schirmer Test

- Without anesthesia
- Measures reflex tear secretion

- With anesthesia
- Basal tear secretion; eliminates stimulated tearing
Tear Osmolarity

- Normal: Under 300 mOsm/L
- Abnormal – 300 mOsm/L or higher
  - Mild: 300-320 mOsm/L
  - Moderate: 320-340 mOsm/L
  - Severe: 340 mOsm/L or higher
- Or Intra eye difference of 8 mOsm/L or more

Effect of tear osmolarity on repeatability of keratometry for cataract surgery planning

Alice T. Epitropoulos, MD, Cynthia Matossian, MD, Gregg J. Berdy, MD, Ranjan P. Malhotra, MD, Richard Potvin, OD

PURPOSE: To evaluate the effects of tear osmolarity on the repeatability of keratometry (K) measurements in patients presenting for cataract surgery.

SETTING: Three clinical practices.

DESIGN: Observational prospective nonrandomized study.

METHODS: Subjects were prospectively recruited based on tear osmolarity (Tearlab Osmolarity System); that is, osmolarity more than 316 mOsm/L in at least 1 eye (hyperosmolar) and osmolarity less than 308 mOsm/L in both eyes (normal). The baseline K value was measured, and a second measurement was taken on the same instrument (IOLMaster) within 3 weeks of the first. Variability in average K, calculated corneal astigmatism using vector analysis, and intraocular lens (IOL) sphere power calculations were compared between groups.

RESULTS: The hyperosmolar group (50 subjects) had a statistically significantly higher variability in the average K reading ($P = .05$) than the normal group (25 subjects) and a statistically significantly higher percentage of eyes with a 1.0 diopter (D) or greater difference in the measured corneal astigmatism ($P = .02$). A statistically significantly higher percentage of eyes in the hyperosmolar group had an IOL power difference of more than 0.5 D ($P = .02$). No statistically significant differences were present when the subjects were grouped by self-reported dry eye.

CONCLUSIONS: Significantly more variability in average K and anterior corneal astigmatism was observed in the hyperosmolar group, with significant resultant differences in IOL power calculations. Variability was not significantly different when subjects were grouped by self-reported dry eye. Measurement of tear osmolarity at the time of cataract surgery planning can effectively identify patients with a higher likelihood of high unexpected refractive error resulting from inaccurate keratometry.

Financial Disclosure: Drs. Epitropoulos, Matossian, Berdy, and Malhotra received compensation from Tearlab for participating in the study. No author has a financial or proprietary interest in any material or method mentioned.

Hyperosmolarity is associated with variability in K measurements.

**Figure 1.** Absolute difference in mean K measured between visits.

**Figure 2.** Vector magnitude of corneal astigmatism difference between visits.
Sources of Error

• Poor tear film and dry eye syndrome.
• If the topography is not optimal, consider addressing the tear film and reassess at a later date.
• Use only select technicians
• Measure before drops
When to Repeat Measurements

- Readings are **Inconsistent** between measurements.
  - Most commonly due to OSD

- **Steep or Flat Eyes**
  - $< 40.0\, \text{D}$ or $> 47\, \text{D}$

- **Difference in Corneal Power** between the eyes.
  - $> 0.9\, \text{D}$

- **High Astigmatism** for either eye
  - $> 2.50\, \text{D}$

- **Small or Large Eyes**
  - Corneal diameter $< 10.75\, \text{mm}$ or $> 13.0\, \text{mm}$. 
Hot spots and Irregularly shaped placido disk is abnormal!

*Repeat testing after treatment!!*

Courtesy of Elizabeth Yeu, MD
LIPIVIEW II MEIOBOGRAPHY

EARLY MGD

STRUCTURAL CHANGE (DUCT DILATION, GLAND ATROPHY, DROPOUT)
Identify Influential Factors for the Dry Eye Condition

- Visual Tasking (e.g., PC use)
- Systemic Medications (e.g., anti-histamines)
- Alcohol (e.g., beer)
- Arid Conditions (e.g., Midwest)
- Windy Environments (e.g., AC, forced heat)
- Pollutants (e.g., exhaust, smog)
Pre-operative Screening and Avoidance!

1. OSDI
2. Thorough history and exam!
3. Tear Osmolarity
4. Inflammadry
   • MMP-9 Detector
Questions?
Phacoemulsification Parameters
Phacoemulsification

- Principle from dentistry – Dr. Charles Kelman
- Longitudinally oscillating tip in the ultrasonic range
- 28 – 45,000 Hz
  - Jackhammer - direct mechanical impact of the physical striking of needle
  - Cavitation - implosion of microbubbles, creating wave of heat and pressure
Principles of Phacoemulsification

- **Followability**: combination of attracting fragments to the tip against the repulsive action of ultrasound
- **Stroke length**: length of the needle movement
  - Power setting on machine reflects stroke length
- **Use minimal amount of power/energy to emulsify the nucleus**
  - Source of heat and possible wound burn
  - Endothelial cells and blood-aqueous barrier
  - Alter amplitude, duration and delivery
Phacodynamics

- Term coined by Dr. Barry Seibel
- Physics of closed-system phacoemulsification surgery
- Safe and efficient removal of cataract through a small incision with minimum disturbance to the eye.
- Fluidics: describes the balance of fluid inflow and outflow.
2 Components

Fluidics
Ultrasound
Fluidics
The Foot Pedal

- Position 1 – Irrigation ONLY
- Position 2 – Irrigation + Aspiration (NO US)
- Position 3 - Irrigation + Aspiration + US
Fluidics – Creation of Balance
Fluid In = Fluid Out

- **Maintain Space**
  - Keep the eye inflated, prevent collapse

- **Create Currents**
  - To bring cataract pieces to phaco probe
  - To remove the cataract pieces

- **Keep Things Cool**
  - To prevent thermal injury to the eye
The Pump

Creates Vacuum and Flow

2 Types of Pumps

1. Peristaltic
2. Venturi
The Fluid Pump - PERISTALTIC

- Fluid bottle
- Irrigation line
- Ultrasound
- Power Wire
- Phaco probe
- Fluid Pump
- Phaco Machine
- Vacuum line
- Irrigation / position 1
- Vacuum / position 2
- Phaco / position 3
- Foot pedal
- Waste Fluid

This slide is © Uday Devgan, MD
Peristaltic Pump

Phaco Aspiration Tubing connected to Phaco hand-piece

Pinch Rollers Compress Phaco Tubing and ‘Milk’ Fluid

Rotation of Rollers

Fluid Drainage Bag

This slide is © Uday Devgan, MD
Holding Power in a Peristaltic System

Occlusion is REQUIRED for Grip

This slide is © Uday Devgan, MD
Occlusion is Essential!
Tip Angles

*Courtesy of Barry Seibel. Phacodynamics
Tip Angles

*Courtesy of Barry Seibel. Phacodynamics*
Peristaltic Pump Vacuum Levels

- **Non-occluded phaco tip:**
  - Vacuum = LOW
  - Flow = HIGH

- **Occluded phaco tip:**
  - Vacuum = HIGH
  - Flow = LOW
Vacuum Pump - VENTURI

Flow of Compressed Air (Nitrogen)

- High Pressure Low Velocity
- Low Pressure High Velocity

Vacuum Created

Rigid Drainage Cassette

Phaco Aspiration Tubing connected to Phaco hand-piece

This slide is © Uday Devgan, MD
Venturi Pump Vacuum Levels
Flow Varies with Vacuum Level – It’s Not Independently Adjustable

**Non-occluded phaco tip:**
- Vacuum = HIGH
- Flow = HIGH

**Occluded phaco tip:**
- Vacuum = HIGH
- Flow = LOWER
Comparison of Pumps

**wPeristaltic Pump**
- Flow Based
- Vacuum created on occlusion of phaco tip
- Flow is constant until occlusion
- Drains into a soft bag

**wVenturi Pump**
- Vacuum Based
- Vacuum created instantly via pump
- Flow varies with vacuum level
- Drains into a rigid cassette
Tubing Size and Tip Size
Flow is related to tubing size

Poiseuille’s Equation

\[ F = \frac{\Delta P \pi r^4}{8 \eta L} \]

- \( F \) = flow
- \( \Delta P \) = pressure gradient
- \( r \) = radius of the tube
- \( \eta \) = viscosity of fluid
- \( L \) = length of the tube
Flow is related to tubing size

**Relative Flow vs. Phaco Needle Diameter**

- **Relative Flow (%)**
- **Phaco Needle Diameter (mm)**

The graph shows a significant increase in relative flow with increasing Phaco needle diameter. This indicates a direct relationship between the two variables.
Flow is related to tip size

0.9 mm tip

- diameter = 0.9 mm
- radius = 0.45 mm
- \( \text{radius}^4 = 0.0410 \text{ mm}^4 \)

Relative flow = 45% versus 1.1 mm tip

1.1 mm tip

- diameter = 1.1 mm
- radius = 0.55 mm
- \( \text{radius}^4 = 0.0915 \text{ mm}^4 \)

Relative flow = 100% versus 1.1 mm tip
Surge – A Big Problem!!

If \textbf{OUTFLOW} > \textbf{INFLOW} then you get surge

- AC instability and collapse
- Risk of capsule rupture

Make sure \textbf{INFLOW} is always GREATER than \textbf{OUTFLOW} to prevent surge

- Use stiff / rigid / low compliance tubing
- Machine venting / bypass tips / etc
The problem of Surge

wOne Source of Fluid INFLOW:
  • Bottle of Balanced Salt Solution
    • Bottle Height
    • Size (radius) / Bore of tubing and phaco needle
The problem of **Surge**

**Two Sources of Fluid OUTFLOW:**
- Aspirated fluid via the phaco probe
  - Flow rate (cc/minute)
- Loss of fluid from incision leakage
  - Tightness of incisions
Preventing Surge

- Keep INFLOW > OUTFLOW

• Very important to prevent surge
Physics of Tubing
Inflow & Outflow Tubing Comparison

Plastic Tubing is FLEXIBLE (Compliant)
Collapsed Tubing Stores Energy

Occlusion of Tubing/Tip with Cataract

Compliant Tubing Collapses and Stores Energy

Post-Occlusion SURGE when Tubing Rebounds
Make the Outflow Tubing Rigid / Low Compliance
Cross Section of Phaco Tubing

- **Irrigation Tubing (inflow)**
  - Larger Diameter
  - Higher Flow
  - Thinner Walls
  - High Compliance
  - Softer

- **Aspiration Tubing (outflow)**
  - Smaller Diameter
  - Lower Flow
  - Thicker Walls
  - Low Compliance
  - Hard / Rigid

This slide is © Uday Devgan, MD
Outflow Tubing is Much Smaller than Inflow Tubing
MICS
MicroIncisional Cataract Surgery

Coaxial vs Bimanual Technique
MICS: Coaxial & Bimanual

Both techniques are moving towards smaller incisions (MICS)

Coaxial Irrigation AND Split Irrigation

This slide is © Uday Devgan, MD
The One Problem with MICS

Smaller Incisions = Smaller Tubing

Very Slow!
The One Problem with MICS

Smaller Incisions = Smaller Tubing
Flow is related to tubing size

FOR INFLOW

Poiseuille’s Equation

\[ F \propto \Delta P \cdot r^4 \]

- \( F \) = flow
- \( \Delta P \) = pressure gradient
- \( r \) = radius of the tube

\( \Delta P \) = determined by Bottle Height
\( r \) = determined by inflow tubing size and inflow irrigating instrument
A high pressure gradient can be **dangerous!**

- Forceful jet of fluid entering eye
- Can damage intra-ocular structures

[Image of firefighters with a high-pressure hose]

Forceful Jet of Fluid (like a Fire Hose)
Preventing Surge: Raise Inflow

- Keep **INFLOW** > **OUTFLOW**

- Maximum Reasonable Inflow Rate for MICS = 35 to 45 cc/min
Preventing Surge: Lower Outflow

Keep **INFLOW** > **OUTFLOW**

- Tighter incisions (prevent leaks)
- Restrictive Outflow Tubing
Phaco Machines

Alcon Centurion
Johnson and Johnson Signature
Bausch and Lomb Stellaris
Alcon Fluidic Innovations
Occlusion of the tip with Cataract & Vacuum Builds
But Fluid Still Flows Through the ABS Hole

Un-occluded, fluid flows through the phaco tip at low vacuum.
Occlusion of Tubing/Tip with Cataract

Fluid Flows Through ABS Hole and Tubing Collapse is Decreased

LESS Post-Occlusion Surge when Tubing Rebounds

Alcon Infiniti ABS Phaco Tip (Aspiration Bypass System)
## Compare current fluidics systems with Active Fluidics™

<table>
<thead>
<tr>
<th>For Phaco Procedures</th>
<th>CENTURION® Vision System</th>
<th>INFINITI® Vision System</th>
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<tbody>
<tr>
<td>Fluidics</td>
<td>Active *</td>
<td>Gravity</td>
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<tr>
<td>Fluidics Monitored During Procedure</td>
<td>Surgeon observation, Software Works to Maintain Target IOP</td>
<td>Surgeon Observation</td>
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<tr>
<td>Pressure Monitored</td>
<td>Software Works to Maintain Target IOP</td>
<td>Irrigation &amp; Aspiration</td>
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<tr>
<td>IOP Ramp</td>
<td>Yes</td>
<td>No</td>
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<td>Customized Patient Eye Level</td>
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<tr>
<td>Irrigation Pressure</td>
<td>Software Works to Maintain Target IOP</td>
<td>Bottle Height</td>
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<td>Irrigation Factor</td>
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<td>No</td>
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<tr>
<td>Aspiration Pump</td>
<td>Balanced Dual Segment Peristaltic</td>
<td>Balanced Dual Segment Peristaltic</td>
</tr>
<tr>
<td>Leakage Compensation</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

**CENTURION® Vision System Graphic User Interface (GUI)**
What is Active Fluidics?

1. SET: The surgeon selects
   1. target IOP
   2. irrigation factor
   3. leakage flow rate
2. MONITOR: Monitors 3 dimensions:
   1. Aspiration Flow Rate
   2. Infusion Pressure
   3. Vacuum
3. ADJUST:
The system automatically adjusts fluid compression in the bag and pump flow rate to maintain the target IOP.
4. RESULT:
   - Less fluid displacement
   - Stable AC
CDE is significantly lower with Active Fluidics/Balanced Tip

- **Infiniti**: mini-flared 45-degree Kelman tip
  - 130 micron swing

- **Centurion**: INTREPID\(^\text{®}\) balanced tip
  - 190 micron swing

*Alcon*
How do fluidics alter CDE?

Comparison of cumulative dissipated energy between the Infiniti and Centurion phacoemulsification systems.

Chen M¹, Anderson E², Hill G³, Chen JJ⁴, Patrianacos T².

Erratum in
Erratum: Comparison of cumulative dissipated energy between the Infiniti and Centurion phacoemulsification systems [Corrigendum]. [Clin Ophthalmol. 2015]

Abstract
PURPOSE: To compare cumulative dissipated energy between two phacoemulsification machines.

SETTING: An ambulatory surgical center, Honolulu, Hawaii, USA.

DESIGN: Retrospective chart review.

METHODS: A total of 2,077 consecutive cases of cataract extraction by phacoemulsification performed by five surgeons from November 2012 to November 2014 were included in the study; 1,021 consecutive cases were performed using the Infiniti Vision System, followed by 1,056 consecutive cases performed using the Centurion Vision System.

RESULTS: The Centurion phacoemulsification system required less energy to remove a cataractous lens with an adjusted average energy reduction of 38% (5.09 percent-seconds) (P<0.001) across all surgeons in comparison to the Infiniti phacoemulsification system. The reduction in cumulative dissipated energy was statistically significant for each surgeon, with a range of 29%-45% (2.25-12.54 percent-seconds) (P=0.005-<0.001). Cumulative dissipated energy for both the Infiniti and Centurion systems varied directly with patient age, increasing an average of 2.38 percent-seconds/10 years.

CONCLUSION: The Centurion phacoemulsification system required less energy to remove a cataractous lens in comparison to the Infiniti phacoemulsification system.
Johnson and Johnson Sovereign and Whitestar Fluidic Innovations
Keep INFLOW > OUTFLOW

- The higher the vacuum level during occlusion, the more potential for surge

*Abbott Medical Optics*
Johnson and Johnson Fluidic Software

- Anticipates the Occlusion Break
- Proactively Drops the Vacuum Level *before* occlusion breaks to limit surge
- Reacts as fast as 0.025 seconds
Johnson and Johnson Fluidic Software

At occlusion break intraocular pressure plunges, shallowing chamber

Pic from AMO
Both Peristaltic and Venturi Options

The WHISTESTAR Signature® System features the ability to switch between a true peristaltic pump and true venturi pump on-the-fly. During a procedure, the surgeon can switch instantly into venturi mode for additional vacuum and holding power. This capability can be extremely useful in multi-surgeon environments and teaching institutions, allowing the flexibility to use both modalities in one system.

- On-the-fly switching between flow-based peristaltic and vacuum-based venturi pumps all-in-one cassette
- Safety of system at high vacuum is maintained
- Pump choice can be preprogrammed by mode or submode
- Aspiration capabilities
  - Peristaltic flow up to 60 cc/min
  - Peristaltic maximum vacuum of 650 mm Hg
  - Venturi vacuum up to 600 mm Hg

* Johnson and Johnson
ELLIPS® FX Technology

ELLIPS® FX Technology is uniquely designed to deliver smooth cutting and excellent efficiency - all without having to change your preferred technique.

- Superb, leading-edge performance and efficient lens extraction
- Simultaneous blending of transversal and longitudinal modalities
- Enhanced followability and effectively holds fragments at the tip end
- Smooth, efficient cutting for hard and soft lenses
- Exceptional versatility with curved or straight tip styles to match your preferred technique
B&L Millennium and Stellaris Fluidic Innovations
B&L Millenium
Restrictive Outflow Tubing

• Smaller Diameter / Bore
• Filter to Prevent Clogging by Cataract Pieces
B&L Flow Restrictive Tubing Prevents Surge

It Keeps **INFLOW > OUTFLOW**

To make up for flow restriction, higher vacuum levels are needed
Peristaltic and Venturi Coaxial and Biaxial

An Integrated Platform For 1.8 mm MICS™

Only Bausch + Lomb can deliver the complete suite of products that finally makes 1.8 mm cataract surgery a reality. The Stellaris Vision Enhancement System can be used in concert with the AcrSys A3 Micro Incision Lens, “AcrSys MICS,” specialized STORM Ophthalmic 1.8 mm instruments, ArtMyc™ PLUS Viscoelastic and benchmark Bausch + Lomb support to provide surgeons and patients with the far-reaching benefits of cataract surgery through a smaller incision.

Coaxial or Biaxial
More Flexibility for MICS Procedure

Vacuum-Based StableChamber™ Fluidics

The Vacuum Fluidics Module goes beyond “Venturi” and provides enhanced control of rise times, holding force, followability, and aspiration for efficient lens removal.
- Solid chamber stability is achieved throughout the procedure for increased predictability
- Vacuum levels of up to 600 mmHg can be delivered with steady low flow for efficient MICS²
- StableChamber tubing controls flow in high vacuum settings preferred for MICS

Flow-Based StableChamber™ Fluidics

The Advanced Flow Module allows intra-operative toggling between flow and vacuum modes while accurately monitoring and maintaining targeted vacuum and intra-operative aspiration rates.
- Monitors vacuum levels in flow mode and controls vacuum in vacuum mode for predictable performance
- Regulates aspiration flow once occlusion breaks, stabilising the anterior chamber for increased surgeon control

*Bausch and Lomb
Advanced Waveform Modulation Software

*Improved Followability*

A unique combination of waveform duration and depth increases phaco efficiency.

*Bausch and Lomb*
Ultrasound Energy
Ultrasound Energy

**Stroke creates:**
- mechanical impact
- cavitation / implosion
- fluid and particle wave
- heat (side effect)

**Stroke Variables:**
- Frequency of impact
- Length of stroke
- Movement of tip while delivering stroke
Ultrasound Energy

Cavitation:

• negative pressure bubbles
• implosion effect at tip

Picture from AMO

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Ultrasound Energy

Phaco Creates a Repulsive Effect (Jack-Hammer)
Ultrasound Energy

Phaco Can Create **Heat**
Be Careful!

Heat can **BURN** the Cornea in seconds

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Preventing Incision Burns

- Good Fluid Flow
- Increases Heat Dissipation
- Slightly Leaky Incision
- Lower Power Settings
- Decreases Heat Production

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Benefits of Decreased Phaco Time
Benefits of Decreased Phaco Time

- Less trauma to Corneal Endothelium
- Minimal endothelial cell loss
- Prevent PBK
Benefits of Decreased Phaco Time

- Clear Corneas immediately after surgery
- Clear Corneas and good vision on postoperative day 1
- High patient satisfaction
Protecting the Corneal Endothelium

w1. Use a good quality viscoelastic.
w2. Keep away from the cornea during phaco.
w3. Decrease the amount of phaco energy and the phaco time that you place in the eye.
APT: Absolute Phaco Time

wAPT is a measure of the total phaco energy delivered into the eye

wAPT is the equivalent phaco time at 100% phaco power

wAPT = Phaco Time x Average Phaco Power
APT: Absolute Phaco Time

\[ w_{APT} = \text{Phaco Time} \times \text{Average Phaco Power} \]

- 15 seconds $\times$ 100% power = 15 seconds APT
- 30 seconds $\times$ 50% power = 15 seconds APT
- 60 seconds $\times$ 25% power = 15 seconds APT

To Decrease APT:
- decrease Phaco Time
- decrease Average Phaco power
How to Decrease Phaco Time and Energy
How to decrease phaco time and energy

Mechanical Nucleus Disassembly

- Use a chop technique
- Less grooving if doing Divide & Conquer
- Switch from 4 quadrant Divide & Conquer to Stop-and-Chop
- Avoid one-handed Phaco
Phaco Chop

How to Understand and Learn a New Way to Phaco Chop:
Step-By-Step:
Chopper & Phaco Tip Placement
D. Brian Klm
How to decrease phaco time and energy
Less time on the foot-pedal

- Phaco only on the forward strokes during grooving (in Divide & Conquer)
- Phaco only when the phaco tip is occluded with nuclear material
- Pulse the foot-pedal
- Goal: Phaco-Assisted Aspiration of Nucleus
How to decrease phaco time and energy
Decrease the Max Power Setting

Set the Maximum Phaco Power setting to about double your average phaco power level
How to decrease phaco time and energy

Phaco Power Modulation

Using the new Advanced Phaco Power Modulation Software
Benefits of Power Modulation

- Decrease Phaco Energy and Time
- Keep phaco tip cool
  - Important in sleeveless bimanual surgery
- Make nucleus removal quicker and easier
- Custom Fit tailored to each surgeon
Basic Types of Power Modulation

Phaco Continuous

Phaco Pulse

Phaco Burst

Effect of Pushing the Foot Pedal down

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Phaco Continuous

Foot Pedal Depression in Position 3

Continuous Energy Delivery
Variable Power depending on foot pedal depression

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Phaco Pulse

Pulsed Energy Delivery
Variable Power depending on foot pedal depression

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Phaco Burst

Foot Pedal Depression in Position 3

Burst Energy Delivery
Variable Burst Interval depending on foot pedal depression
(every burst will have the same power)
Advanced Power Modulation

**wHyper Settings**
- Pulse Mode: Up to 120 Pulses/second
- Burst Mode: Duration as low as 4 milliseconds

**wVariable Duty Cycle**
- for pulse mode and as an end-point in burst mode

**wPulse Shaping Methods**
- For packets of energy or for each pulse/burst
Grooving / Sculpting

Like a finely serrated knife, high pulse rates give the cutting feel of continuous energy.
Effect of Pulses/Second (PPS)

Changing the PPS will **not** magically decrease the APT:
Effect of Pulses/Second (PPS)

Changing the PPS will not magically decrease the APT:

The Total Amount of Phaco Energy delivered is EQUAL.
Programming via Rates
10 Pulses/Second
40% duty cycle

Direct Programming
40 msec ON time
60 msec OFF time

Depends on Duty Cycle
Program On/Off Time
Variable Duty Cycle

In Pulse Mode, the default duty cycle is 50%

Ratio of ON to OFF is 50:50, hence 50% duty cycle
We can change the duty cycle to 20%.

The ratio of ON to OFF is 20:80, hence 20% duty cycle.
Variable Duty Cycle

Benefits of a lower duty cycle:
- MORE cooling of the phaco needle
- LESS phaco energy delivered into the eye
- MORE time for aspirating the nucleus
Variable Duty Cycle

**ON time:** - Ultrasound Energy Delivered
- Jack-hammer Repulsion Effect
- Heat Generated

**OFF time:** - Aspiration of Nuclear Fragments
- Cooling of Phaco Tip
- No Ultrasound Energy

50% duty cycle
20% duty cycle

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B&L Custom Control Software

Pulse Shaping: Variable Rise Time

w Ramping-Up each pulse

Example at 2 Pulses/Second
pulse shaping: variable rise time

w ramping-up a packet of phaco energy

250 msec on heat 250 msec off cool 250 msec on heat 250 msec off cool

0 sec example at 2 pulsed packets/second 1 sec
Benefits of Variable Rise Time

- Decreases the amount of phaco energy delivered into the eye

B&L Custom Control Software

Square Wave Pulses

Phaco Energy Saved

Ramped-Up Pulses

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Benefits of Variable Rise Time

- Reduces the repulsive effect of phaco
  
  High phaco power pushes the nuclear pieces away
Benefits of Variable Rise Time

Ramp-up draws the nuclear pieces into the phaco tip

Then higher phaco power is immediately applied to emulsify and aspirate the nuclear pieces.
Phaco Power Modulation

• ‘Custom Fit’ tailored to the surgeon
  • Pulse / Burst / Traditional
  • Multiple parameters are variable

• Allows minimizing the phaco energy
  • Clear Corneas / quick healing
  • Good vision on Post-Op Day #1
  • Happy patients that build your practice
Examples
Starting with Divide and Conquer

Divide and Conquer
Cataract Extraction

Christopher Teng, MD
David Chang Illustrating PhacoChop Technique
The good, the bad, and the ugly...
Other tools... MiLoop
Becoming a BETTER Phaco Surgeon!
Steps to decreasing phaco time & energy

1. Mechanical nucleus disassembly (chop)
2. Less time on the foot-pedal
3. Decrease the Max Phaco Power setting
4. Phaco Power Modulation
   • Pulse Mode & Burst Mode
5. Advanced Power Modulation
   • Hyper Settings, Variable Duty Cycle, Pulse Shaping, Other Modalities of Energy Delivery
Fluidics is all about BALANCE
Great Surgery is all about Efficiency!

Efficient Fluidics + Efficient Phaco Power = Efficient Surgery
Wrap-up Questions
What percentage of cataract surgery patients have signs of ocular surface disease?

A. Less than 5%
B. 10-20%
C. 20-30%
D. 30-40%
E. Greater than 50%
Which formula below can be most broadly applied to MOST eyes?

A. Holladay I
B. Hoffer
C. SRK/T
D. Barrett
E. Olsen
All of the following are screening tools for ocular surface disease before cataract surgery except:

A. Tear osmolarity  
B. Pachymetry  
C. Inflammadry (MMP9 assay)  
D. Schirmer Test  
E. Tear break up time  
F. Questionaires (OSDI or SPEED)
Additional questions?
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