Cataract Surgery Update

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Cataract surgery is one of the most common procedures performed worldwide/year.
21st Century Cataract Surgery
Femtosecond Laser Assisted

- In the past 35 years, significant changes
- Intracapsular surgery
• In the past 30 years, significant changes
• Extracapsular surgery
21st Century Cataract Surgery
Femtosecond Laser Assisted

- In the past 30 years, significant changes
- Phacoemulsification surgery
In the past 30 years, significant changes

- Femtosecond Laser Assisted Surgery
21st Century Cataract Surgery
Femtosecond Laser Assisted

- Laser (light amplification by stimulated emission of radiation) is used in many areas of Ophthalmology
- Femtosecond uses similar wavelength to Nd:YAG
- Much less tissue damage due to short duration of pulse
21st Century Cataract Surgery
Femtosecond Laser Assisted

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21st Century Cataract Surgery
Femtosecond Laser Assisted

- A femtosecond is one quadrillionth of a second: \(1 \times 10^{-15}\)
- YAG laser is in nanoseconds: \(1 \times 10^{-9}\)
- Works through a process of photodisruption
- Thousands of pulses per second creates precise tissue dissection
21st Century Cataract Surgery
Femtosecond Laser Assisted LASIK Flap

- Thousands of pulses per second creates precise tissue dissection
- Can be used in cornea and lens surgery
Advancements in intraocular lenses (IOLs) and cornea-based laser refractive surgery have promoted a merger of cataract and refractive surgery.
21st Century Cataract Surgery
Femtosecond Laser Assisted

- People have grown accustomed to laser precision for vision correction
- High quality uncorrected distance vision with less spectacle dependence with new generation implants will be a goal for more patients
Femtosecond Lasers
Built in OR Table
Femtosecond Lasers
OR Chair
Femtosecond Lasers
Femtosecond Lasers
Femtosecond Lasers

- Corneal folds were identified in 70% of the CCL cohort; 63% of these had areas of incomplete capsulotomies beneath the corneal folds
- No corneal folds or incomplete capsulotomies were identified in the LOI cohort

JCRS: April 2013
Femtosecond Lasers

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JCRS: April 2013
Femtosecond Lasers

- The mean eye movement during capsulotomy creation (1.5 sec) was 50 µm with a CCL and 20 µm with an LOI
- The LOI cohort had 36% less subconjunctival hemorrhage than the CCL cohort

JCRS: April 2013
LensAR Imaging

- Scheimpflug imaging
- 3-dimensional confocal structured illumination
- High definition imaging through all degrees of nuclear density
LensAR Docking

- Topical anesthesia
- Minimal increase in intraocular pressure
- Liquid interface without tissue distortion
- Docking and treatment takes 2-3 minutes
- Subconjunctival heme is common
Advanced Docking

- Alternate docking mode
- Displays force gauge
- Regulated by the “Robo-Cone” to maintain a constant 4 ounces
- Will deactivate during PID locking lever engagement
- Then will maintain close to 4 ounce reading
• Software collates the multiple acquired images to generate an exact reconstructed model of the anterior segment
LensAR 3D image

- Software takes into account any lens tilt
- Default anterior capsular clearance of 250 microns from pupillary edge
- Default safety clearance from posterior capsule of 1000 microns
Proposed treatment plan is superimposed on 3 dimensional model
LensAR Imaging

3D CSI
Ideal Capsulotomy

- Consistent size, shape
Diameter Accuracy

Capsulotomy Diameter Accuracy
(Absolute difference between Attempted and Achieved)

Only 10% of manual rhesis achieved diameter accuracy of +/- 0.25mm
Ideal Capsulotomy

- 360 degree optic overlap
Ideal Capsulotomy

- Tear resistant
Argentinian flag sign
LensAR capsulotomy

Superior?

- **Strength:** twice as strong in laboratory testing in pigs; may *not* be as strong in humans
- **Size:** ten times more stable (manual increases in size over first 4 weeks postop)
- **Shape:** automated
- **Centration:** computer guided
- **Accuracy** reduces possibility of implant decentration or tilt
Lens Capsule Anatomy

Graph showing capsule thickness (µm) across the lens from anterior pole to posterior pole. The graph includes data from Salzmann at 10, 23, 37, and 52 years, and Fincham from Table III & Fig. 26, as well as Fincham's Diagram Fig. 3.
Lens Capsule Anatomy

Maximum Capsular Thickness
5.25 mm diameter
LensAR capsulotomy
LensAR Phacofragmentation Patterns
LensAR PhacoFragmentation Patterns

- Softening for a hard cataract
- Segmentation for a soft cataract
Custom Fragmentation

- New Chop/Fragmentation feature
- Selects between one of four pre-programmed patterns based on cataract density
- Accessed via Patient Entry screen or via Surgery Profile
Custom Fragmentation

- Category 1 – Low Density, No Nucleus
- Category 2 – Low Density, Nucleus Present
- Category 3 – High Density, Nucleus Present
- Category 4 – High Density, Unable to Image Nucleus Separately
Custom Fragmentation

- When surgery proceeds to the laser/phaco page can see Category and pattern selected based on patient’s biometry and surgeon specified fragmentation patterns
Femto Phacofragmentation Patterns

LASER FRAGMENTATION
Femtosecond Clear Cornea Incision
Femtosecond Clear Cornea Incision
Astigmatism Management

![Diagram showing a comparison between a "Sleeker" and a "Flattened" shape.](image-url)
Astigmatism Management

- LRI
- Toric IOL
Femtosecond LRI

- Accurate depth and optical zone, 90% depth
- Full effect of incision not achieved until opened
- Accurate axis?
LRI
LRI Marking
LRI
Cassini Topography

- Color LED topography
- Colored lights projected on to the cornea
- Similar to placido disc, but yields information on front and back surface
- Instant, not prone to movement artifact
- Info on total cornea area
Customized AK

- Import diagnostic data from the Cassini
Iris Registration for AK

- Iris registration image
- Surgeon AK image
Wireless Cassini Data Transfer Process

- At the Laser/Phaco page, “Do Iris Registration” needs to be pressed prior to running the surgery to allow for compensation for any cyclotorsion.
Approaches to LRI/IOL Alignment

Iris Fingerprinting
Cassini system

- Automatically registers the pre-op topography and an eye image to the live 3D view of the eye
Approaches to LRI/IOL Alignment

Iris Fingerprinting
Cassini TrueVision 3D system
From topographer image to LENSAR image – freckles indicate rotation of $3.0^\circ$ clockwise. Iris registration algorithm computed a rotation of $3.5^\circ$ clockwise.
Approaches to LRI/IOL Alignment

Iris Fingerprinting

Cassini TrueVision 3D system

• LensAr image after iris registration and nomogram adjustment with compensation of 7 degrees of cyclorotation
Customized AK

Wireless Cassini Data Transfer Process

- Algorithm results are shown in the upper left hand screen of the main image of the eye.
- Any recalculations are also posted.

### Image

- **CYCLOTORSION**: 7.1°
- **ASTIGMATISM**: 0.50 @ 174
- **AKs**: 0.0
Customized AK

- Then press Surgeon Table button on Patient Entry Screen
Customized AK

- Can adjust CCI position based on astigmatism treatment if needed/desired
- New AK positions automatically recalculated based on Surgeon Table
Custom AK

- ATR and WTR graphs can be filled out
- Any current or personal nomogram can be programmed
LensAR in the OR
Corneal Reference Marks
LensAR in the OR

From LensAR to Microscope
LensAR in the OR

Hydrodissection
LensAR in the OR

Nuclear Fracture Completion
21st Century Cataract Surgery
Femtosecond Laser Assisted

- Reduced Cumulative Dissipated Energy (CDE): 50-60% in dense cataracts
- Reduced Effective Phaco Time (EPT)
- Reduced corneal swelling
- Reduced wound burn
Reduced Cumulative Dissipated Energy (CDE): 50-60% in dense cataracts

Reduced Effective Phaco Time (EPT)

Reduced corneal swelling

Reduced wound burn
Femtosecond Laser Complications

- Partial/ decentered capsulotomy
- Inadequate fragmentation
- Capsular block syndrome
- Subconjunctival hemorrhage
Femtosecond Laser Complications

- **Partial/ decentered capsulotomy**
- Inadequate fragmentation
- Capsular block syndrome
- ? Increased risk of radial tears
- Subconjunctival hemorrhage
Femtosecond Laser Complications

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- *Subconjunctival hemorrhage*
LensAR Phacoemulsification
Operative Considerations

- Small pupil
- Pupil gauge helpful
- Consider abort laser if < 5.3 mm
LensAR Phacoemulsification
Operative Considerations

- Hydrodissection easier, but potentially more dangerous
LensAR Phacoemulsification
Operative Considerations

- Nucleus easily split
- Reduced phaco time
- Cortical cleanout can be more labored
LensAR Phacoemulsification
Operative Considerations

• Cortical cleanout can be more labored
LensAR in the OR

Cortex Removal
ORA

- Based on Talbot-Moire interferometry
• Reflected wavefront passes through a grating pair – results in diffractive fringe pattern which is translated into the refractive state of the eye using algorithms
THE ORA SYSTEM™

✔ Intraoperative Aberrometry
  — Checks refraction during surgery allowing accurate IOL selection
  — Reduces the gap between targeted and actual refraction
  — Avoids errors based on preop calculations
  — Avoids errors related to surgically induced astigmatism
  — Allows precise LRI adjustment

✔ Targeted Patients
  — Premium IOLs
  — Post LASIK, PRK and RK
  — All LRI patients
  — All patients with uncertain biometry or IOL calculation

✔ Practice Impact
  — Larger IOL inventories needed
  — Fewer enhancement procedures
  — Fewer dissatisfied patients
ORA Outcomes

![Graph showing ORA outcomes.

FIGURE 2  Outcomes with ORA or as predicted by preoperative biometry. (WaveTec Vision data on file.)
ORA Reticle
Intraoperative Aberrometry

ORA
Optiwave Refractive Analysis (ORA)

No Rotation Recommended

Anticipated Residual Cylinder
0.31 X 44°

Measured Residual Cylinder
0.14
ORA Advantages

- 38% switch rate (90% +/- 0.5 diopter)
- Post refractive (diopter switch rate may be large, particularly in post RK)
- Greatly decreases frequency of IOL exchange
- Accounts for SIA on the spot
- No preoperative marking (blade LRI’s)
- Can be used under general anesthesia
- Useful in patients with very dense cataracts in whom optical biometry is not possible
- Useful in uncooperative patients in whom any biometry is not possible
ORA Disadvantages

- Occasional case unreadable
- 2-5% of time astigmatism readings inconsistent with preop
- More viscoelastic often needed
- Decreased work space
- Increased OR time
ORA Disadvantages

- **Beware of outliers** - APHAKIC measurements of
  - $< -5.0$ diopters or
  - $> +20.0$ diopters
  - = go with clinic measurements
ORA Disadvantages

- Beware of using BSS only to pressurize
- Beware of Discovisc and Amvisc-Plus
- Other cohesive viscoelastics are OK
ORA

Stromal Hydration
Intra-operative Wavefront Learning Curve

- Surgeon Factors
- Positioning (hand on head)
- Speculum
- IOP
- Media clarity
- IOL position (pseudophakia)
LensAR in the OR
Open LRI
**Femtosecond LRI**

- Precise depth and optical zone
- Full effect of incision not achieved until opened
- Incisions may be opened like a postage stamp edges under ORA guidance
- Laser will make this more of a science than an artform
- Pre-placed incisions do *not* account for SIA.
**Femtosecond Potential Advantages**

- More predictable and precise cuts
- More predictable outcomes
- Better outcomes
- More candidates for premium IOLs?
- Increased surgeon confidence
- Increased patient satisfaction
Femtosecond Laser Advantages

- Dense cataract
- Endothelial Dystrophy
- Zonulopathy
- Shallow A/C
- Precise LRI
- Premium IOL (theoretic more dependable ELP)
- Can be used under general anesthesia
Femtosecond Disadvantages

- Cost
- Time
- OR scheduling acrobatics
- Anterior capsular tears may be more common if size made too small
- Post femto/pre-phaco induced miosis
- Cosmesis (postop subconj heme)
- +/- discomfort during femto docking
Femtosecond/ORA Complications

First 1000 Cases

- Posterior Capsular Rupture/Vitreous Loss: 0
- Endophthalmitis: 0
- Wound Leak: 0
- Incomplete capsulotomy: 3
  (all with <4.8 mm diameter; unrelated to incomplete)
- Radial Anterior Capsular Tear: 3
- IOL exchange: 0
- Refractive sx enh: 0
Verdict

• Femtosecond laser cataract surgery is safe and effective
• *Probably* improves results with more predictable ELP
• More friendly to eyes with greater internal pathology
• Worth the cost?
• ORA *definitely* improves outcomes