Overview

- Femtosecond Laser Review
- Femtosecond flaps for LASIK
- Femtosecond laser uses in keratoconus
- Keratectomy review
- Intracapsular femtosecond cataract surgery
- Intraocular lens-related keratoplasty
- Femtosecond laser-assisted cataract surgery
- New technology with femtosecond lasers
- Femtosecond laser technology
- Femtosecond Flap Advantages
- Main Surgeon Advantages in Context of Liability
- Reduced Dryness
- Reduced trauma to corneal microvilli
- Better tear film adherence
- Better visual acuity
- More shallow flaps and consistent small diameter
- Reduced corneal nerve damage (depth and diameter) and less induced dryness
- Improved apposition of severed nerve fibers

Photodisruption with a Femtosecond Laser

- Plasma Formation
- Acoustic Shockwave
- Cavitation Bubble Formation and Collapse
- Cut Region Remains

Adapted from Pepose et al, Cataract and Refractive Surgery Today, October 2008

Femtosecond Lasers in Today’s Ophthalmic Surgery

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Financial Disclosures

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  - Speaker Bureau, Allergan

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How fast is a femtosecond?

How far does light travel?

- 1 second = 1,000,000,000,000,000 femtoseconds
- 1 second = 300,000,000 meters
- 1 femtosecond = 300 nanometers
- 1 picosecond = 0.3 millimeters

Photodisruption with a Femtosecond Laser

- Laser focused at a specific depth in cornea
- Creates "cavitation" bubbles of CO₂ and H₂O
- Bubbles merge together with tissue bridges/adhesions
- Bubbles can be focused in a plane or on top of each other
  - Horizontal, vertical, diagonal, round, curved
  - Any X,Y,Z axis configuration

Femtosecond Flap Advantages

- Reliably Thin Flaps
- Tighter standard deviation of desired vs. achieved flap thickness
- Flap Stability
- Reduced risk for flap dislocation (liability)
- Better visual acuity
- Reduced risk for flap dislocations
- Reduced Dryness
- Improved biomechanical advantage
- Better lens contrast sensitivity (night vision)
- Surgery rates
- Laser-induced higher order aberrations
- 82% of LASIK flaps in 2012 were femtosecond flaps

Main Surgeon Advantages in Context of Liability

- Reduced Dryness
- Patient complaints
- FDA LASIK hearings
- Reduced HOAs (compared to blade LASIK) also discussed in FDA LASIK hearings
- Increased biomechanical advantage
- Ectasia risk

Reduced Dryness

- Reduced suction pressure at limbus to reduce goblet cell damage
- Less effect on mucin tear layer
- Reduced trauma to corneal microvilli
- Better tear film adherence
- More shallow flaps and consistent small diameter
- Reduced corneal nerve damage (depth and diameter) and less induced dryness
- Improved apposition of severed nerve fibers

- Schallhorn, S. et al, Ophthalmology, April 2009

+ Biomechanics (safety/reduced risk of ectasia)

- Why Stay Near the Surface?
  - Anterior 40% of Cornea has strongest cohesive tensile strength
  - Posterior 60% of Cornea is 50% weaker than the anterior 40%
  - Increasing age is associated with increased corneal cohesive tensile strength
  - The thinner the flap, the more of the anterior 40% of cornea remains after treatment
  - Improved biomechanical stability, faster adhesion & wound healing
    - John Marshall, PhD

- Thinner Flap
  - Twice as strong as posterior 60%

- Thicker Flap
  - More residual tissue

- Improved biomechanical stability, faster adhesion & wound healing
  - John Marshall, PhD

+ Summary

What to tell Patients?

- Less flap making risk
- Thinner flaps
- Less dryness
- More residual tissue
- More 20/20's & better low contrast [night] vision according to US Navy studies
  - John Marshall, PhD

- Thinner flap with equal ablation depth means MORE of the strongest part (front 40%) of cornea left after treatment

- Femtosecond laser LASIK flap creation

- Femtosecond Laser Keratoconus surgical applications

- Intacs with femtosecond laser created channels

- Keratoconus Review

- Prevalence:
  - 1/2000 - varies

- Genetics
  - 15-70 times more likely to have KC if someone in immediate family has it compared to general population
  - Connection between KC and defects on chromosomes 21, 17, 13
    - Likely multiple genes involved given multiple presentations

- Etiology
  - Keratoconus likely 'causes accelerated keratocyte apoptosis
    - Minor traumas cause epithelial cells to release cytokines leading to apoptosis
  - Often first stromal response to epithelial injury
  - Susceptible corneas may lack ability to process reactive oxygen species due to lack of necessary protective enzymes (e.g., ALDH3 and superoxide dismutase).
Keratoconus Review

- Multiple Presentations
  - May be unilateral (75%) or bilateral
  - May affect the central or mid-peripheral cornea
  - May be mild or severe
  - May start in childhood or later in life
  - May occur in more than one family member or in one individual only

- Hallmarks
  - A decline in visual acuity (usually greater in one eye than the other)
  - A distorted retinoscopy reflex—-a.k.a. “scissors” motion
  - Distortion of or an inability to superimpose the bottom right keratometry cone
  - Frequent changes in spectacle cylinder power and axis.
  - Increased myopia
  - Squinting—pinhole effect
  - Halos/starbursts around light during nighttime viewing
  - Associated astigmatic disease

Femtosecond Keratoconus Surgery: Intacs

- Used to reduce corneal irregularity
  - Some flattening
  - Moves cone more central
  - Provides intrastromal structure to cornea

Intacs Background

- Developed CornealScope in late 1960s—led to today’s topography
- One of the early medical champions of contact lenses in the U.S.
- 1978—Dr. Reynolds’ first conception of Intracorneal Rings

Intacs: Background

- 1980—Kera Associates Formed
  - John C. Petricciani, marketing executive of Bailey-Fairfax
  - Joseph Z. Kreuzvski, Ph.D., ophthalmic pharmaceutical researcher
- 1985—First preclinical studies of ring performed by Dr. Schanzlin and Dr. Flemming
KeraVision Milestones

- 1984 - Intrastromal Corneal Ring
- 1986 - KeraVision Inc. established
- 1988 - Preclinical studies in preparation for FDA
- 1991 - Phase I - First human clinical trials (Brazil, U.S.)
- 1993 - Phase II - 360° ICR myopia trial initiated (U.S.)
- 1994 - Preliminary astigmatism study (Brazil)
- 1994 - Death of Gene Reynolds, OD
- 1997 - Phase III - ICRS
- 1997 - Preliminary Hyperopia studies in Mexico initiated
- 1999 - FDA Approval of Intacs

Adjustable
Ring

Intrastromal
Corneal
Ring

Gapped
Ring

Gapped
Ring

Segments

360 Ring

Intrastromal
Corneal
Ring

Segments
The INTACS Effect

Arc Shortening

Femtosecond laser-enabled Keratoplasty
a.k.a. Intralase-enabled keratoplasty (IEK)

Intacs for keratoconus

Intralase-enabled keratoplasty (Corneal Transplant)

Intacs with femtosecond laser created channels

Femtosecond lasers for KC
Intralase-enabled keratoplasty (IEK)

- Better graft-host fit
- Multiple healing contact interfaces
- Reduced suture tension
- No significant endothelial cell loss
- Faster vision rehabilitation
- Earlier suture removal
+ Femtosecond laser-enabled keratoplasty

+ Astigmatism

Typical 1 yr post-op PKP
standard spheric cut = 6 diopters of astigmatism

Intralase-enabled Keratoplasty
at 3 months post-op = ½ diopter of astigmatism

+ Femtosecond laser-assisted cataract surgery

- Femtosecond Technology
- Same technology as laser flaps for LASIK
- Now approved and will change the future of CATARACT SURGERY
- Incisions
  - Anterior Capsulorhexis
  - Lens Fragmentation
- Relaxing Incisions – UFL’s

+ Advantages of femtosecond laser-assisted cataract surgery

- SAFETY
  - Incisions – perfect wounds, less chance for endophthalmitis
  - Lens Fragmentation – softer nucleus, less time and energy
  - 63% decrease in average phaco time
  - 57% decrease in effective phaco power
- ACCURACY
  - Capsulotomy – precision size & centration, critical for Refractive IOLs
  - Manual: 329 microns; Laser: 27 microns
- OUTCOMES
  - Relaxing Incisions – for astigmatism, with newer IOL technology goal is within 0.50D of emmetropia

+ Intralase-enabled keratoplasty
  - Rapid Rehab

1 week post-op
3 months post-op

+ Femtosecond laser-assisted cataract surgery

- Capsulorhexis Precision
Traditional manual cataract surgery

Femtosecond laser-assisted cataract surgery outcomes

Femtosecond laser arcuate incisions

Femtosecond laser-assisted cataract surgery Capsulorhexis

New Technology

Femtosecond uses:
- Liquefy, soften or “chop” the lens
- Create capsulotomy
- Create all required surgical incisions
- Provide a refractive solution to pre-existing astigmatism by creating relaxing incisions
- Possibly do all above with better accuracy and precision than our current manual techniques?

Femtosecond arcuate incisions

Capsulorhexis Precision

Femtosecond laser-assisted cataract surgery

Femtosecond arcuate incisions

Astigmatic Keratotomy
Femtosecond arcuate incisions

Femtosecond laser pockets for Kamra corneal inlay
- Increased depth of field with minimal effect on distance vision

Femtosecond presbyopia surgery Intracor
- Concentric rings allow for aspheric central corneal steepening
- Similar to collagen shrinkage procedures
- LTK
- CK

Femtosecond laser pockets for Kamra corneal inlay
- Kamra corneal inlay
- Pinhole effect
- Presbyopia
- 5 microns thick
- 3.8mm in diameter
- 1.6mm central aperture

Femtosecond laser surgery for presbyopia Intracor

Femtosecond laser pocket for Kamra inlay
**Femtosecond laser**

Small Incision Lamellar Extraction

a.k.a. SMILE, ReLEx, FLEX

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**SMILE, ReLEx, FLEX**

- Lenticule is removed to allow corneal flattening

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**Summary**

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- Femtosecond laser uses in keratoconus
- Keratoconus review
- Insert for KC with femtosecond channels
- Intracorneal inkeraptomy
- Femtosecond laser-assisted cataract surgery
- New technology with femtosecond lasers
- Intracor
- SMILE, ReLEx, FLEX
- Kamra

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**Thank You!**