Management of Intraoperative Femtosecond LASIK Flap Complications

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Financial Disclosures: Carl Zeiss Meditec, Oyster Point Pharma, Johnson and Johnson, Dermavant
No financial interests in this subject matter

Etiology, Risk Factors, Management and Prevention

- Incomplete and torn flap
- Decentered flap
- Suction loss
- Anterior chamber bubbles

Incomplete and torn flap during Femto LASIK

Etiology

FS laser : photodisruption

↓

Interface of intrastromal gas bubble creating a dissection plane for flap lifting

→

Microbubbles may break vertically through the corneal epithelium during flap creation (vertical gas breakthrough)

↑

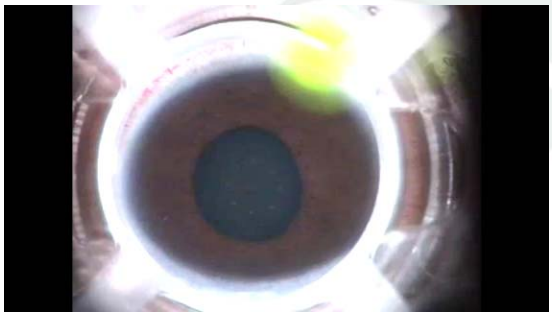
INCOMPLETE FLAP

Risk Factors

FS laser cannot photodisrupt corneal stroma in abnormal area of adherence of the intended interface:

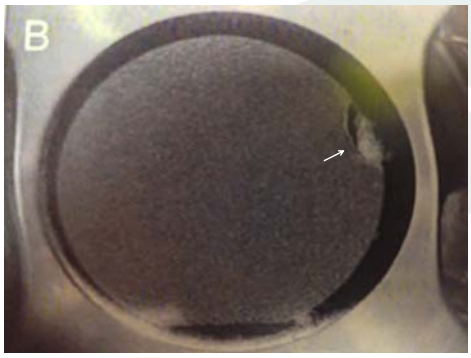
- Ocular rosacea
- Corneal scarring (any focal or diffuse weakening of the corneal stroma)
- Thin flap
- Dense opaque bubble layer (OBL)

Early OBL



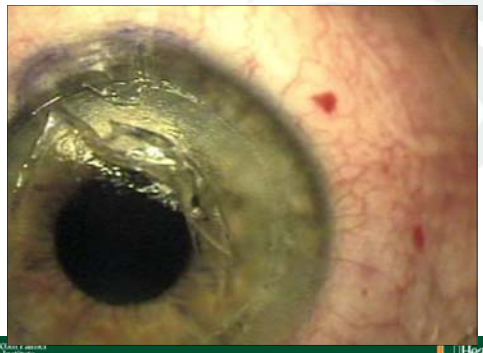
Late OBL

Bubble in epithelium–applanation interface (Vertical Gas Breakthrough)



Bubble in epithelium–applanation interface

Incomplete flap



Management

- If defect noted before flap lifting: avoid standard superior to inferior sweep, lift the flap around the defect to prevent flap tearing

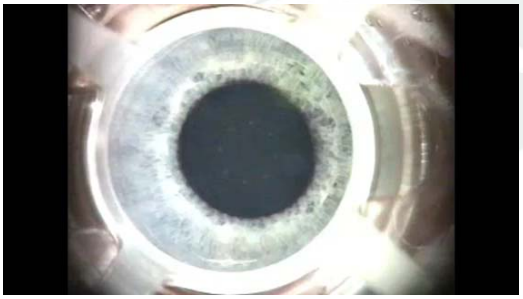
Torn Flap

To prevent incomplete flap

- If mild to moderate corneal scarring: adjust FS energy or use microkeratome
- If severe corneal scars: no femtoLASIK
- If the scars are anterior: increase flap thickness to have a flap interface posterior to the scarring

Decentered Flap

Decentered Flap



Decentered Flap

- Decentered Suction Ring
- Decentered Pupil
- Parallax Error
- Suction Ring Slippage
- Risks of Using Centration Software
  - Shrinking Flap Diameter
  - Error in Direction, Number of Clicks (0.25 mm/click) horizontally and 0.35 mm vertically)

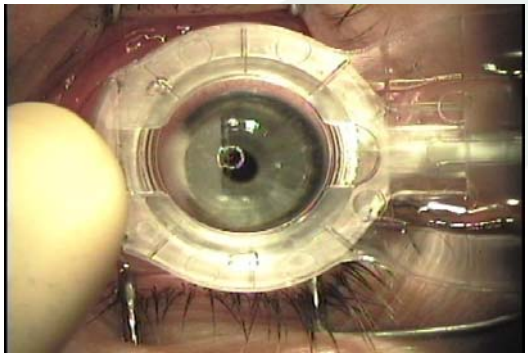
Suction Loss

Suction Loss

Suction Loss

- Although uncommon, suction loss is the most frequent cause of interrupted procedures
- Master the fundamentals of the joystick to avoid suction breaks
- Some manufacturers recommend that when a suction break occurs, the procedure should be reattempted immediately while bubbles are still present.

Re-centering after a Suction Break



Suction Break-During Raster

Perform the next steps immediately, while gas bubbles are still present

Select Cancel on menu box *(not "re-start")*

Use the same Applanation Cone to re-establish the same depth

Use new Suction Ring Assembly

Select "Adjust Params," turn pocket off

Once docked, use arrow buttons to align/center previous treatment bubble pattern with yellow overlay

Suction Break-During Raster

- Next step options:
  1. If suction loss reoccurs after 3 attempts, abort procedure and ask the patient to return the following day, week, or month.
  2. Upon return use a different depth at least 40 microns away from the original depth.
  3. Consider surface ablation

Suction Break-During Side Cut

Select Cancel: Same cone, new suction ring

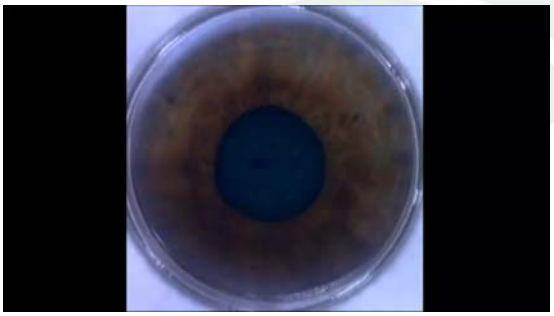
Select "Side Cut Only"

Note: if side cut option does not appear after selecting "adjust params" move the cursor over the patient data box and click the left mouse button before pressing Ctl-alt-S

Decrease flap diameter by 0.5 mm

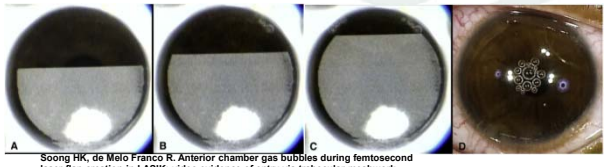
Use arrow buttons to align/center previous treatment bubble pattern with yellow overlay (original side cut & bubble pattern should be larger than yellow overlay to avoid crossing side cuts)

Anterior Chamber Bubbles



Mechanism of AC Bubble Formation

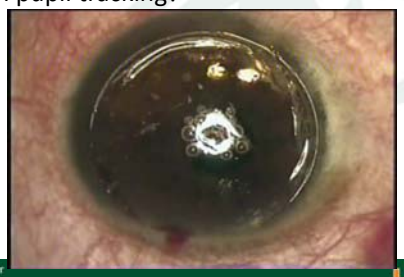
Proposed mechanism: Gas travels peripherally along the corneal lamellar plane of the stroma, into the episclera, and then into the anterior chamber via the trabecular meshwork



Soong HK, de Melo Franco R. Anterior chamber gas bubbles during femtosecond laser flap creation in LASIK: video evidence of entry via trabecular meshwork. J Cataract Refract Surg. 2012 Dec;38(12):2184-5.

Anterior Chamber Bubbles

- What do you do about AC bubbles interfering with pupil tracking?



What Next?

1) Advance Patient Waiting Area?

2) Abort Procedure until Another Day?

3) Dilate Pupil Tracking?

4) Remove Bubbles With 30 G Needle?

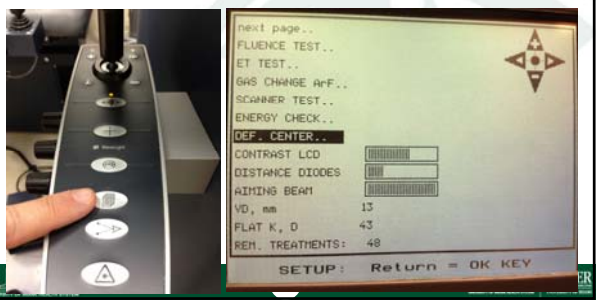
Intracameral Bubbles migrate Under the Corneal Apex Blocking the Tracker

Courtesy of Ron Krueger and Brad Kligman

Corneal Vertex Centration

Steps in Performing a Centration Adjustment:

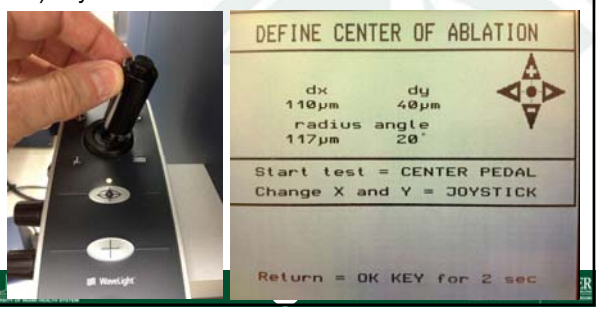
1) Locate Proper Screen for Defining Centration



Corneal Vertex Centration

Steps in Performing a Centration Adjustment:

2) Joystick Offsets Centration in 10 um Increments



AC Bubble Management

- Wait for bubbles to resolve
- Turn off tracker
- Have patient move eyes rapidly left and right, then tap on ocular surface to break surface tension of multiple gas bubbles and cause them to coalesce into smaller, less numerous bubbles. Illumination in excimer operating microscope dimmed (to dilate pupil)
- Careful use of mydriatic (center of pupil may move)
- Corneal Vertex Centration can be used to offset asymmetrical pupil dilation
- I do NOT recommend AC tap


Thank You
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Imaging for LASIK and Its Complications

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- Dermavant
- Johnson and Johnson

Imaging for LASIK and Its Complications

- Topography
- Tomography
- Wavefront or Ray Tracing (Higher Order Aberrations)
- Anterior Segment Optical Coherence Tomography (AS OCT)

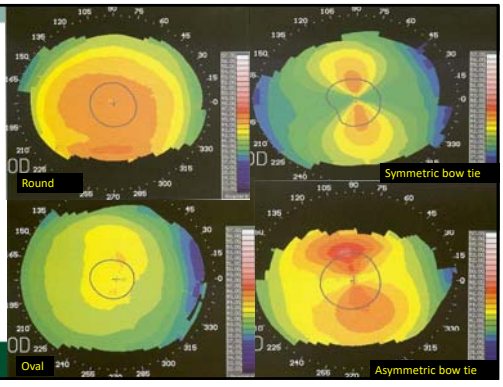
Role of Corneal Topography in Refractive Surgery

- Preoperative
  - Screening for ocular disease: KCN, other corneal abnormalities
  - Planning the surgery
- Postoperative
  - Documentation of effects of surgery
  - Investigation of poor outcome
  - Planning for enhancements
  - Biometry for cataract surgery

Normal Cornea

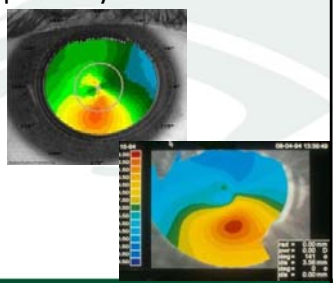
Bogan et al Classification

- Round
- Oval
- Symmetric bow tie
- Asymmetric bow tie
- Irregular

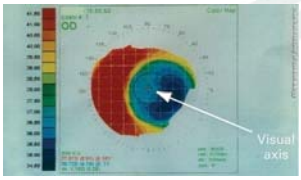


Corneal Shape Analysis

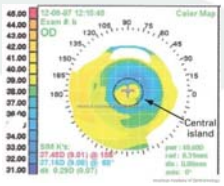
- Recognition of pathological patterns
  - It is important to recognize particular pathological patterns that are associated with poor refractive surgery outcomes.
  - Forme fruste or fully expressed keratoconus pattern
    - Characterized by inferior steepening
    - Keratorefractive surgery performed in such cases is associated with a higher risk of keratectasia and postoperative topographic instability



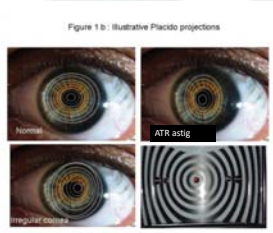
Postoperative Topography



Decentered Ablation

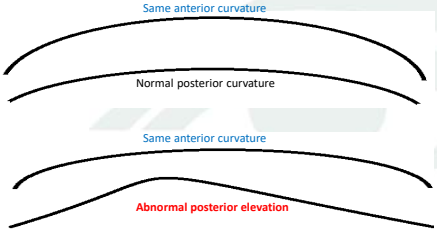


Central Island



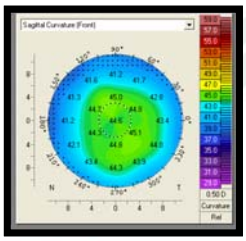
Tomography

- Projection-based systems can generate 3D recreation of anterior segment to measure anterior and posterior elevation, pachymetry. ie. Orbscan, Pentacam, Galilei

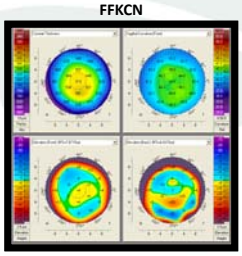


Tomography

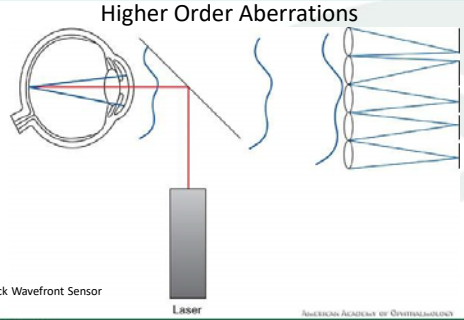
Is this normal?



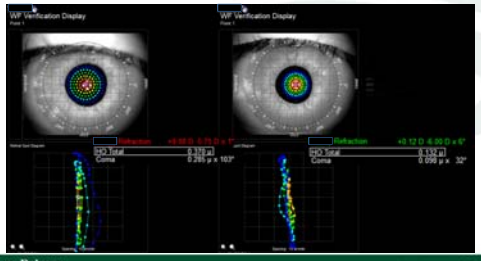
FFKCN



Higher Order Aberrations



Ray Tracing



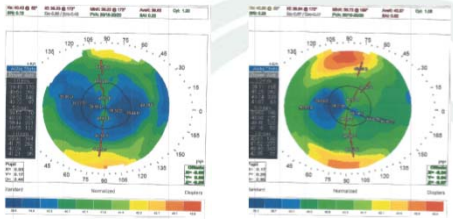
Wavefront Testing

- The wavefront is usually reconstructed using Zernike polynomials
  - These polynomials are then used to describe the wavefront by its components
  - Fourier analysis is another mathematical system that has been used to reconstruct the wavefront
- Aberrations are divided into lower and higher order
  - Lower order are sphere (defocus) and cylinder
  - Higher order encompass all other ocular aberrations

Wavefront Testing

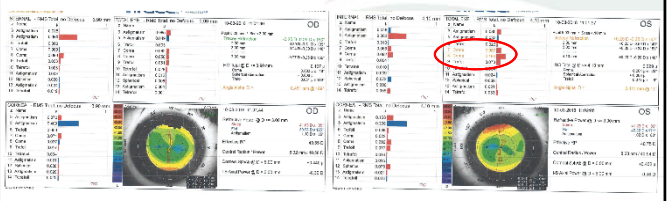
- Display of the wavefront
  - Typically made with a color coded map, with elevation above and below a perfect "flat" wavefront. A map is usually displayed for all aberrations and a second map of higher aberrations.
  - Can also be displayed as a point spread function. This is the calculated appearance of a point source of light.
- Higher order aberrations are generally increased after conventional laser vision correction.
  - In particular, spherical aberration can be increased when treating myopia. Amount of increase is related to the level of treated myopia

30 yr male s/p LASIK OU with blurry vision OS UCVA 20/20 each eye



OD OS

Coma



WF Case #2

- 28 yo male presenting at BPEI for refractive surgery evaluation
- POHx: none
- PFHx: father with PKP OU for KCN

Refraction

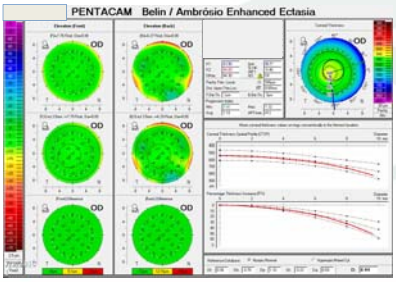
UCVA
Right 20/400
Left 20/400

Manifest Refraction
Right -4.75 sphere 20/20
Left -5.50 sphere 20/20

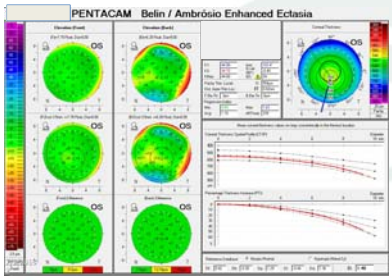
Wearing Rx
Right -4.75 sphere 20/20
Left -5.25 sphere 20/20

Cycloplegic Refraction
Right -4.75 sphere 20/20
Left -5.50 +0.50 020 20/20

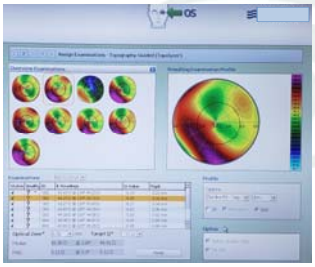
Tomography OD



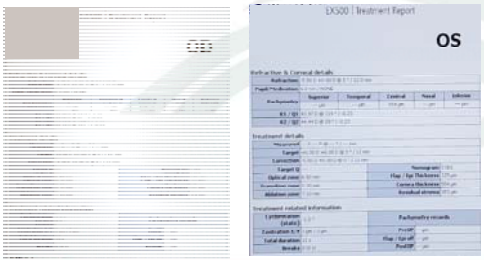
Tomography OS



Wavefront analysis



Treatment: PRK OU



POM#1

- 20/20 J1+ OU
- Patient happy but complaining about some glare/halos at night

AS-OCT Advantages

- Non-contact
- Corneal and Anterior Segment Resolution
- Penetration through Corneal opacities & scars
- Quick Acquisition Time (to minimize movement errors)
  Visante OCT Line Scan = .125 sec, Quad Scan = 0.5 sec

OCT Case #1 Preop evaluation

- 28 yo female presented at BPEI for refractive surgery evaluation.
- POHx: corneal scar OS for presumed CL related corneal ulcer 10 years ago
- PFHx: no h/o KCN

Refraction

- **UCVA**: 20/800 OD and 20/400 OS
- **Manifest Refraction**

	Sphere	Cylinder	Axis	Dist VA
Right	-5.25	+0.50	100	20/20
Left	-4.25	+0.25	105	20/20

- **Cycloplegic Refraction #2 (Subjective)**

	Sphere	Cylinder	Axis	Dist VA
Right	-4.75	Sphere		20/20
Left	-5.00	+0.75	105	20/20-

Refraction

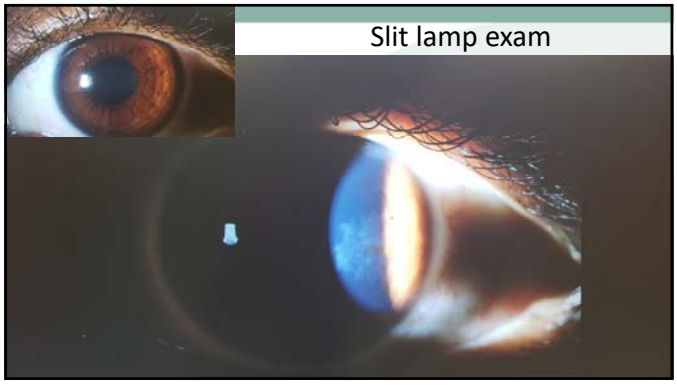
- **Wearing Rx**

	Sphere	Cylinder	Axis
Right	-5.25	+0.50	095
Left	-4.75	+0.75	105

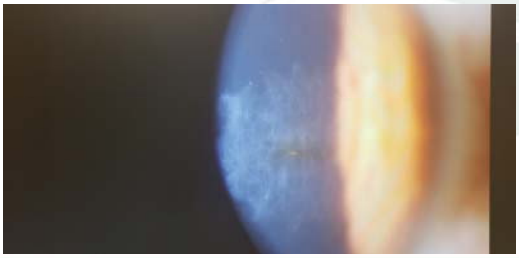
- **Current Contact Lens Rx**

	Brand	Sphere
Right	Dailies Spherical	-5.25
Left	Dailies Spherical	-4.75

Slit lamp exam

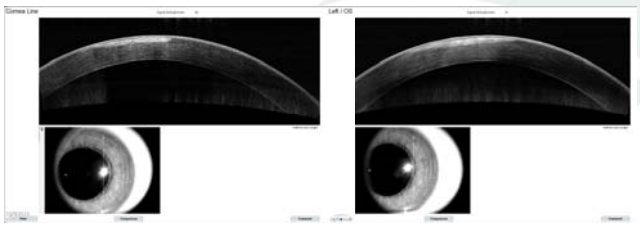


Slit lamp exam



Topography

AS-OCT



Central Pachymetry: 602/604 microns
Thinnest pachymetry in regard of scar: 592 microns

Given unclear h/o corneal ulcer OS, patent paracentral stromal scarring but 20/20 BCVA OS,

what should we do ?

Treatment plan

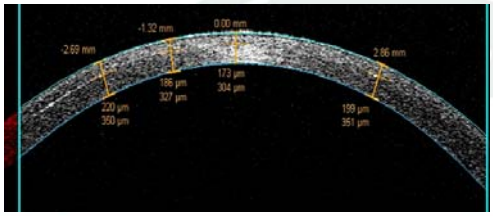
- LASIK OD
- Transepithelial PRK OS
  - 50 microns to remove epithelium and smoothen Bowman's/anterior stroma
  - Full treatment
- Patient informed that residual ref error + visual disturbances may occur postoperatively OS>OD

- POD #4 20/20 OD
  20/200 OS with central KED and paracentral residual scar
- POM #1 20/20-1 OS

LASIK Enhancement Evaluation

- 31 yo female s/p myopic LASIK 10 years ago
- Initial Rx:
  OD -5.50 +0.75 x 110 (67 microns)
  OS -4.50 +0.50 x 70 (58 microns)
- Current MRx:
  OD -2.25 + 1.00 x 97
  OS -1.50 sph
- Pachy 482 microns OD

AS-OCT analysis



Surgical plan for enhancement

- Femtosecond (IntraLase) flap creation
  8.0mm edge cut only, 200µm deep, nasal hinge,hinge angle 45o, side cut energy 2.3
- Wavefront enhancement

Target refraction: -2.38/+1.14x98

Ablation depth: 38µm

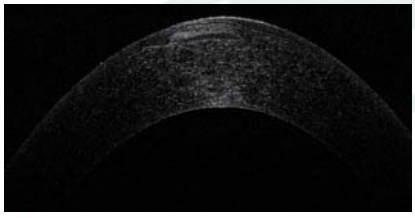
Optical zone 6mm, transition zone 8mm

Femto Side Cut Video

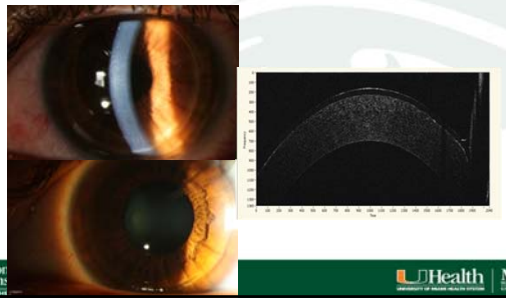
LASIK Flap Complication

- 36 yo male s/p aborted LASIK 6 m ago due to incomplete flap
- BCVA 20/50, vision worsening

SD OCT



Flap Amputation with PTK



Case (17 y male with right amblyopia)

Visual Acuity (Snellen - Linear)

	Right	Left
Dist cc	20/60 +2	20/20
Dist ph cc	20/50	

Correction: Glasses

Manifest Refraction

	Sphere	Cylinder	Axis	Dist VA
Right	-5.25	+5.00	110	20/50-2
Left	-2.25	+0.25	005	20/20

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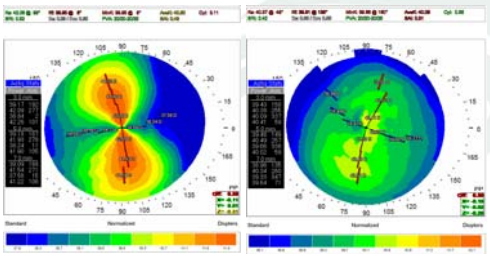
OD OS



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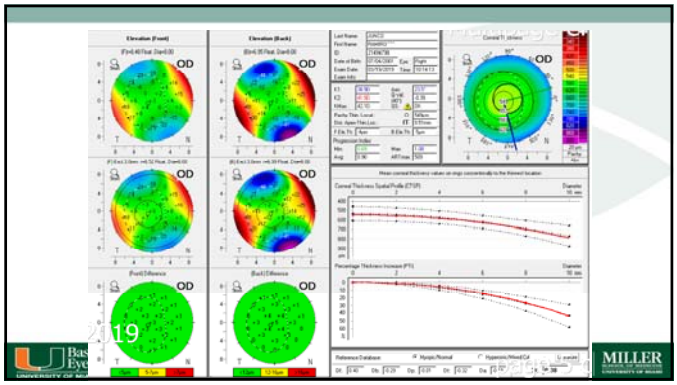
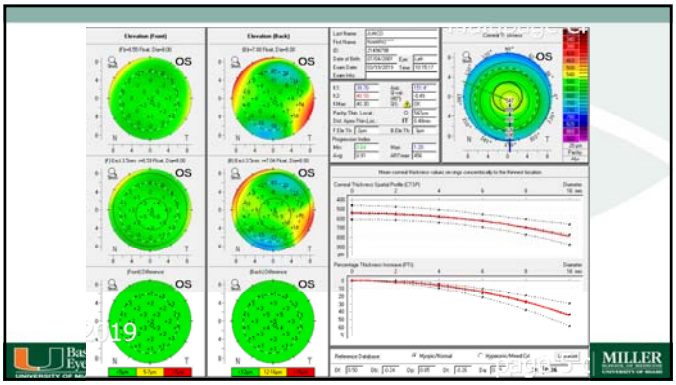
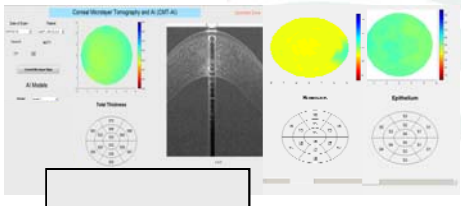




CMLT-AI: OD



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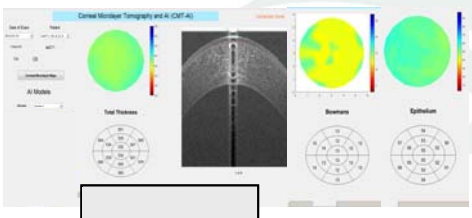
CMLT-AI: OS



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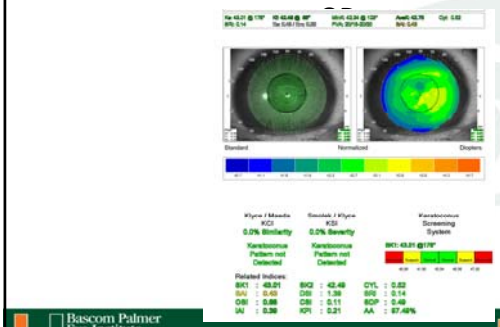
Case (15 y boy with blurry vision)

Manifest Refraction

	Sphere	Cylinder	Axis	Dist VA
Right	-3.00	+0.75	180	20/20
Left	-3.50	+1.00	010	20/30+1



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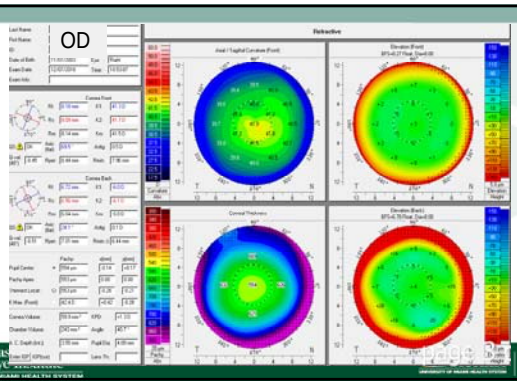

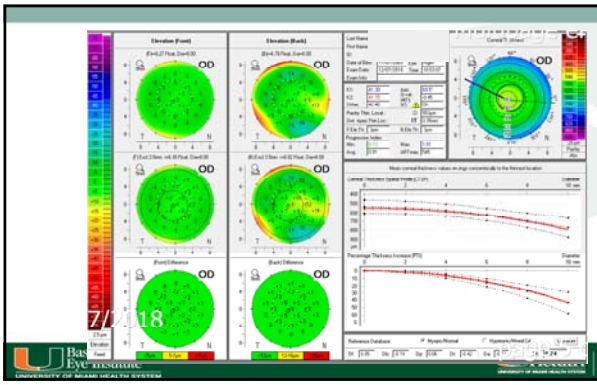

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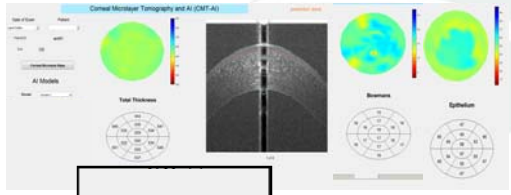

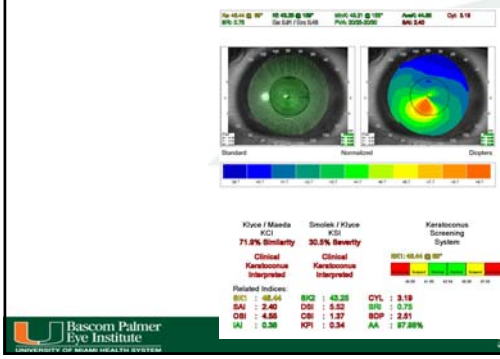

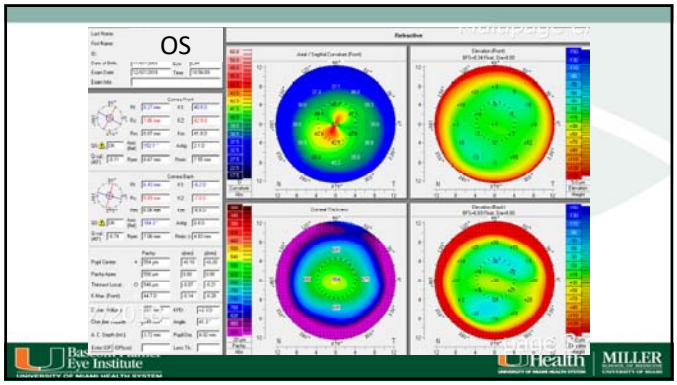

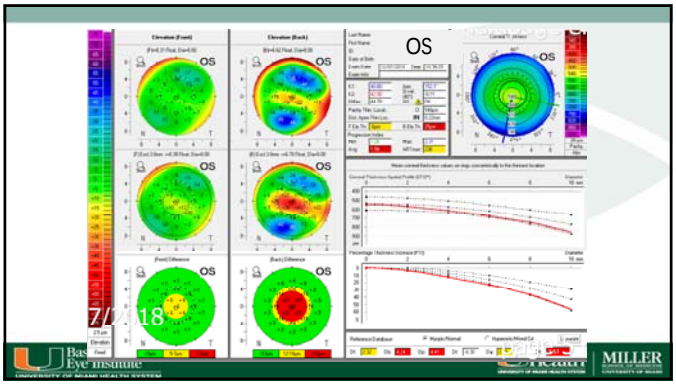

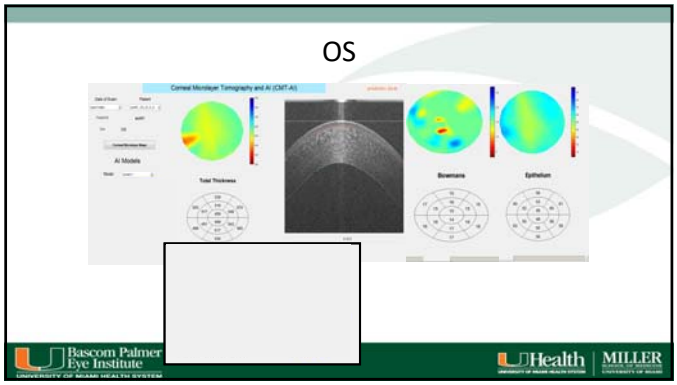

Thank you !

Long-term Outcomes of Flap Amputation after Laser in Situ Keratomileusis

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Background

- LASIK
  - Complications revolve around the creation of a corneal flap
  - Include flap irregularities/abnormalities, astigmatism, over/under correction, dry eye, infection, and epithelial ingrowth
    - Incidence of epithelial ingrowth: 0.03% - 9.1%
      - Twice as frequent after LASIK enhancement
    - Incidence of infectious keratitis: 0.01% - 0.03%

- When corneal flap/interface problems persist, debridement and amputation of the insulting flap might be considered a reasonable intervention
- Flap amputation is considered a last option when alternative treatment options fail

Purpose

- To assess the long-term visual and structural outcomes of flap amputation after LASIK

Methods

- 8 eyes of 7 patients with a history of post-LASIK flap amputation were included
- Flap amputation was performed at Bascom Palmer Eye Institute in Miami, FL, between 1998 and 2013
- Retrospective chart review
  - Reasons for flap amputation, preoperative and postoperative slitlamp examination, visual acuity, optical coherence tomography (OCT, Visante, Carl Zeiss Meditec, Jena, Germany) and corneal topography parameters such as central corneal thickness and keratometry readings (Ks) using Tomey (Nagoya, Japan) were assessed

Results

- 2 eyes had LASIK flap amputation secondary to epithelial ingrowth
- 6 eyes had LASIK flap amputation secondary to infectious keratitis with *mycobacterium* or *acanthamoeba* species

Epithelial Ingrowth: Patient 1

- Ocular trauma 6 years after LASIK
  - Presented with epithelial abrasion and small area of flap edge elevation
  - Treated with antibiotics and corticosteroids
- 1 week later: progressive epi ingrowth and overlying flap melt
  - Flap lift, debridement, flap suturing
- 1 month later: contracture of flap with microstriae
  - → Flap amputation with MMC
- 3 years later: UCVA 20/30 BCVA 20/25

Epithelial Ingrowth: Patient 2

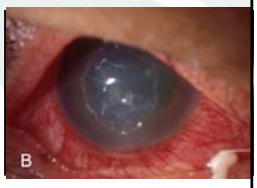
- Suction loss during primary LASIK with resultant temporal flap truncation
  - Presented 2 months later complaining of glare & decreased VA (UCVA 20/80)
  - Slit lamp examination: nests of epithelial cells under the LASIK flap in the visual axis, temporal scarring, and corneal thinning
- CL intolerant, flap architecture was causing irregular astigmatism
  - → Flap amputation with MMC
- 1 year later: UCVA & BCVA 20/30

Infectious Keratitis: Acanthamoeba

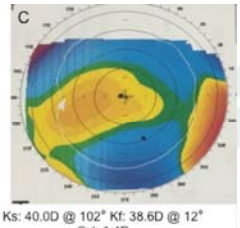
- Diagnosis 10 years after LASIK
  - Presented with pain, redness, photophobia
  - Acanthamoeba keratitis – culture (+)
  - UCVA 20/200
- Treatment
  - Polyhexamethylene biguanide (PHMB) & neomycin q1hr
  - 7 days later: (-) neomycin and (+) chlorhexidine 0.02%
  - Minimal improvement
  - → Flap amputation
- 6 months later: UCVA 20/40 BCVA 20/25

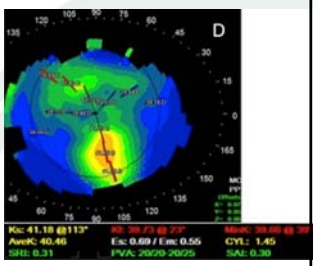
Infectious Keratitis: Mycobacterium

- 5 eyes with *mycobacterium* infection
  - Including *Mycobacterium chelonae, mucogenicum, atypical,* and abscessus
  - Mean UCVA was 20/200
  - Had persistent infection despite medical management (amikacin & clarithromycin)
  - → Flap amputation
- 6 years later: mean UCVA 20/50



Infectious Keratitis: Mycobacterium





1 year after flap amputation

10 years after flap amputation

Conclusion

- We report 8 cases of flap amputation resulting from uncontrolled infectious keratitis or epithelial ingrowth after LASIK
- Despite the complicated course of these patients, all achieved good visual acuity after flap amputation

Discussion

- Final refractive trend in our patients: hyperopic astigmatism or mixed astigmatism
  - May be due to epithelial changes
- Secondary procedures in those with bothersome residual refractive error / scarring can be done

- PTK: to improve superficial scarring and irregular astigmatism (2 of our cases and also reported in the literature)
- PRK: depends on residual cornea thickness (goal of 300 microns)
- Corneal topography-guided transepithelial PRK: improves irregular astigmatism and BCVA after flap amputation (1 case in literature; not available in USA)

Thank You!

Acknowledgements

References

- 1. Wilson SE. LASIK: management of common complications. Laser in situ keratomileusis. Cornea 1998; 17:459-467.
- 2. Gimbel HV, Penno EE, Van Westenbrugge JA, et al. Incidence and management of intraoperative and early postoperative complications in 1000 consecutive laser in situ keratomileusis cases. Ophthalmology 1998; 105:1839-1848.
- 3. Melki SA, Azar DT. LASIK complications: etiology, management, and prevention. Surv Ophthalmol 2001; 46:95-116.
- 4. Kamburoglu G, Ertan A. Epithelial ingrowth after femtosecond laser-assisted in situ keratomileusis. Cornea 2008; 27:1122-1125.
- 5. Stulting RD, Carr JD, Thompson KP, et al. Complications of laser in situ keratomileusis for the correction of myopia. Ophthalmology 1999; 106:13-20.
- 6. Machat J. The Art of LASIK; LASIK Complications. Thorofare, NJ, Slack, 1999.
- 7. Solomon R, Donnenfeld ED, Azar DT, et al. Infectious keratitis after laser in situ keratomileusis: results of an ASCRS survey. J Cataract Refract Surg 2003; 29:2001-2006.
- 8. Suarez E, Cardenas JJ. LASIK; Principles and Techniques. Thorofare, NJ, Slack, 1998.
- 9. McLeod SD, Holsclaw D, Lee S. Refractive, topographic, and visual effects of flap amputation following laser in situ keratomileusis. Arch Ophthalmol 2002; 120:1213-1217.
- 10. Sun Y, Jain A, Ta CN. Aspergillus fumigatus keratitis following laser in situ keratomileusis. J Cataract Refract Surg 2007; 33:1806-1807.