"2020 and Beyond Surgical Innovations and Updates"
COPE# 69249-PO

Josh Johnston, OD, FAAO

Disclosures for Josh Johnston, O.D., F.A.A.O.

- Allergan- Consultant, speaker, research
- Astareal- consultant
- Avellino- consultant
- Azura- consultant, speaker
- BioTissue- consultant
- Bruder- consultant
- Dompe- consultant
- Glaukos- consultant, speaker
- Horizon Therapeutics- consultant
- Kala- consultant
- LacriSciences- share holder
- Legrande Health
- Sight Sciences- consultant
- Maxi Vision- consultant
- Novartis- consultant
- Sun- consultant, speaker
- Tarsus- consultant, researcher
- Visus- consultant
- Quidel- consultant, speaker
- Zeiss- consultant

Optometric Co-management

- High quality eye care
- Benefits to patient care
  -
  -
  -
  -
- Utilize skills and expertise of each practitioner

Today's Optometrists

"To be on the cutting edge of optometry, you need to be on the cutting edge of science and technology."

2.0 B

People with Presbyopia around the globe in 2019 – growing to

2.3 B

by 2023

PRESBYOPIA Worldwide

Presbyopes	2019	2024
US	128.7 M	136.5 M
OUS	1.93 Billion	2.17 Billion

Source: 2019 Market Scope Estimates

~ 1.8 million new presbyopes a year in U.S.

Contributing Factors:

- **Aging population**
- **Longer life expectancies**
- **Longer Working Careers**
- **Near Vision needs**
- **Growing Middle Class in emerging markets**

Why Is This Important For Optometry?

- 4 out of 5 patients diagnosed with a cataract are done so by an optometrist
- Optometrists are the "gatekeepers" to cataract referrals and ATIOLs
- Referring O.D.'s must discuss all IOL options and educate patients about cataract and treatment options

Patient Education

- Elements of effective education
- Explain the condition
  -
  -
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- Four presbyopic IOL classifications
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Expect (Avoid) the Unexpected!

- Pre-op for Lifestyle IOLs
  - Topography, ocular surface testing
  - Macular OCT
  - Reliable biometry, reproducible astigmatism measurements
- Under promise and over deliver for ATIOLs
  - Emphasize need for +1.00 readers for near tasks ***
  - Discuss starbursts around lights at night

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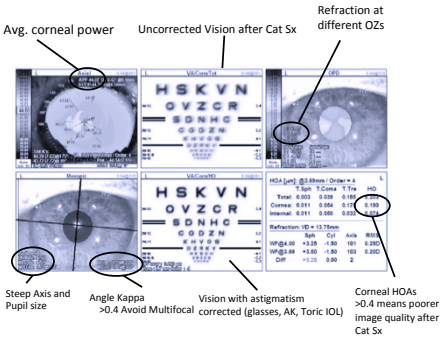
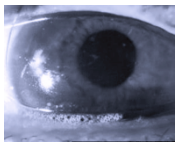
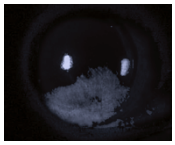


Preparation for Ocular Surgery

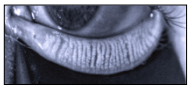
- Optimize the Ocular Surface
- Normalize the Lids
- Prepare the Cornea
- Eliminate Intra-ocular Inflammation
- Control Glaucoma
- Satisfy the Macula
- Evaluate the Retinal Periphery
-

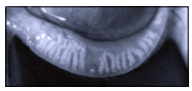




Dry Eye Disease

- Chair time: blurred vision from cataracts versus DED
- Cataract sx can worsen DED for months after surgery
- Quality of vision may require chronic DED therapies





ARTICLE

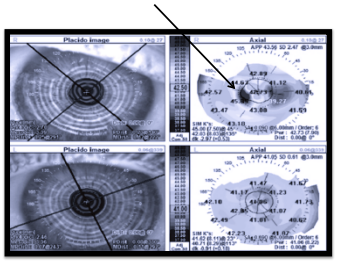
Prevalence of ocular surface dysfunction in patients presenting for cataract surgery evaluation

Preey ... *n, BS,*

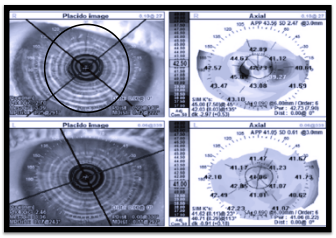
Results: There were 120 patients (69% women), mean age 69.5 years ± 8.4 (SD). Abnormal osmolarity was found in 68 patients (56.7%), and abnormal MMP-9 in 76 patients (63.3%). Clinical findings showed that 47 patients (39.2%) had positive corneal staining on presentation, 9 patients (7.5%) had epithelial basement membrane dystrophy, and 2 patients (1.6%) had Salzmann nodules. Questionnaire data showed 54 (54.0%) of 100 patients reported symptoms suggestive of ocular surface dysfunction. In the asymptomatic group of 46 patients, 39 (85%) had at least 1 abnormal tear test (osmolarity or MMP-9) and 22 (48%) had both tests abnormal. Overall, 96 (80%) of 120 patients had at least 1 abnormal tear test result suggestive of ocular surface dysfunction and 48 patients (40%) had 2 abnormal results.

J Cataract and Refractive Surgery 2018

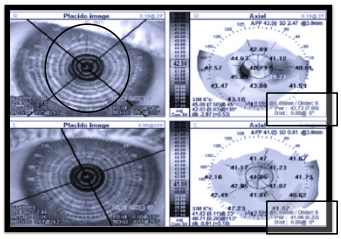
"Hot spots" and "Flat spots" are abnormal

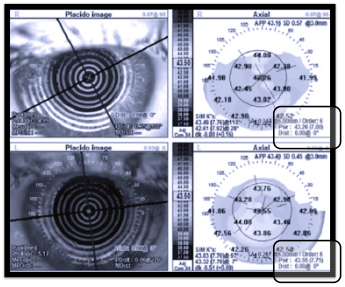


Irregularly shaped or smudgy placido disk is abnormal!



Take a closer look if <u>average</u> K values are different





REVIEW/UPDATE

An algorithm for the preoperative diagnosis and treatment of ocular surface disorders

Christopher E. Starr, MD, Preeya K. Gupta, MD, Marjan Farid, MD, Kenneth A. Beckman, MD, Clara C. Chan, MD, FRCSC, Elizabeth Yeu, MD, José A.P. Gomes, MD, PhD, Brandon D. Ayers, MD, John P. Berdahl, MD, Edward J. Holland, MD, Terry Kim, MD, Francis S. Mah, MD, the ASCRS Cornea Clinical Committee

An algorithm for the preoperative diagnosis and treatment of ocular surface disorders
Starr, Christopher E. et al.
Journal of Cataract & Refractive Surgery, Volume 45, Issue 5, 669 – 684 2019

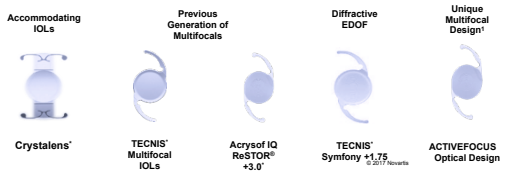
Premium IOLs: 5 Pearls ("P's") for Success

1. **P**lano Outcome
2. **P**roactive Tx of Ocular Surface Disease
3. **P**re Op Counseling – Setting Realistic Expectations
4. **P**roperly Screen Candidates
5. **P**ick the Right IOL

Other:
6. **P**ick the Right Surgeon
7. **P**osterior Capsular Opacification
8. **P**oor IOL Centration

ATIOLs Provide The Opportunity to Treat More Than Just the Cataract

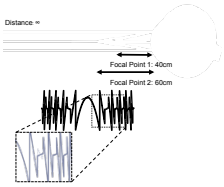
What are your patient's post-op visual goals?



1 Alcon Data on File April 2016

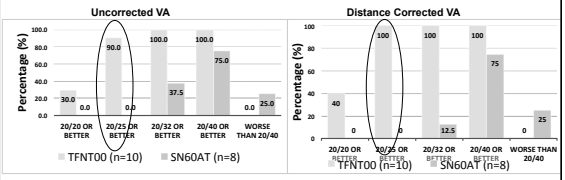
PANOPTIX TRIFOCAL IOL

- **SUPERPOSITION OF FOCAL POINTS**
- **LIGHT REDIRECTION** point redirected to distance
- **3 FOCI** – Trifocal with 40cm, 60 cm and distance
- **88% LIGHT UTILIZATION** - at 3.0 mm pupil
- **LIGHT ALLOCATION** - 50% of available light to distance, 25% to intermediate and 25% to near

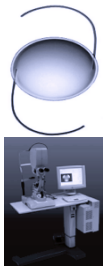


Composite Binocular VA at all three distances (distance, intermediate and near) at 6 month

Proportion of patients that achieved a certain VA at all tested distances

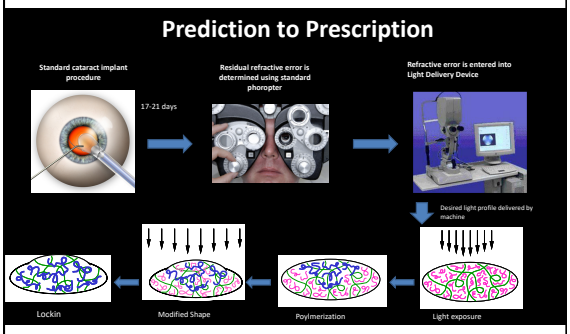


Light Adjustable Lens (LAL)

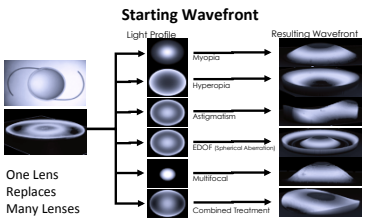


- FDA Approved 11/17 for pts with pre-existing astigmatism of ≥0.75D undergoing cat sx
  - Spherical and cylindrical errors up to 2D
- First and only lens designed to be ***adjusted*** after implantation by UV light
- 3 piece IOL design
- 6.0mm biconvex optic; 13.0mm overall length
- UV absorbing back layer: 50-100 µm

Prediction to Prescription



Flexible Treatment Profiles



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RxLAL Will Expand Monovision Use

- [1]
  -
  -
  - [2]
  -
  fusion

IOL Type	Refractive Error (Standard Deviation)
Non-Adjustable	0.5D
RxLAL	0.2D

- **RxLAL will dramatically increases binocular accuracy**
  - Standard deviation reduced to 0.2D[1]
  - Patient ability to test-drive/adjust final outcome
  - LASIK-like outcomes
- **Creates new premium channel opportunity**

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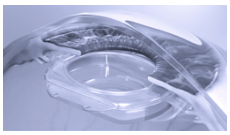
1. 2019/2016 ASCRS Survey 2. Average over all ECAs 3. Ocular Data FDA Study

FDA Clinical Results

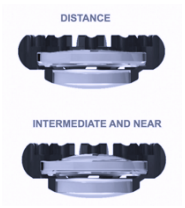
- 91.8% within 0.50 D of target manifest refraction spherical equivalent
- Results showed that 100% of study eyes had a best corrected visual acuity of 20/40 or better at the 6 month po visit.

What's Next in IOL Technology?

- Modular IOL Systems
- Accommodating
- Multifocal / trifocal
- Extended Depth of Focus



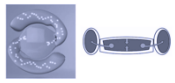
Accommodating IOL – LensGen Juvene



- Modular, curvature-changing, fluid-optic IOL
- Two-part IOL - Base and Modular
- Advantages
  -
  -
  vision
  - No change in ELP
  - No PCO up to 4 years
- Astigmatism?? Drug Delivery?? Exchangeable 2nd implant??

**Not FDA Approved

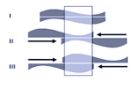
Accommodating IOL – Alcon FluidVision Lens



- Entire lens is hollow and filled with liquid silicone
- Fluid changes changes in optic
- Avg. accommodation range 2D
- Dr. Nichamin ESCRS 2018
  - 29 eyes
  - Distance 20/20
  - Intermediate 20/20-20/25
  - Near 20/22-20/27

**Not FDA Approved

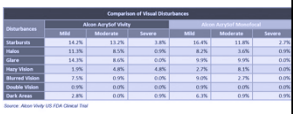
Accommodative IOL – Akkolens Lumina



- Two piece sulcus IOL
  - Fixed and variable
  - Hydrophilic acrylate
- Shifting optics
  - Can provide 3-4 D focal range when shifted
- Dr. Alio -59 eyes of 43 pts
  - Accommodative range of 3.1D

**Not FDA Approved

EDOF - Vivity IOL



Comparison of Visual Disturbances

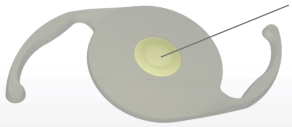
Disturbances	Alcon AcrySof Vivity			Alcon AcrySof Monofocal		
	Mild	Moderate	Severe	Mild	Moderate	Severe
Starbursts	14.2%	13.2%	3.8%	16.4%	11.8%	2.7%
Halos	11.3%	8.5%	0.9%	8.2%	3.6%	0.9%
Glare	14.3%	8.6%	0.0%	9.9%	9.9%	0.0%
Hazy Vision	1.9%	4.8%	4.8%	2.7%	8.1%	0.0%
Blurred Vision	7.5%	0.9%	0.0%	9.0%	2.7%	0.0%
Double Vision	0.9%	0.0%	0.0%	0.9%	0.0%	0.0%
Dark Areas	2.8%	0.0%	0.9%	6.3%	0.9%	0.9%

Source: Alcon Vivity US FDA Clinical Trial

-
- creates an extended focal range by stretching and shifting the wavefront
- Low incidence of visual disturbances
- Possible for AMD?? Glaucoma??

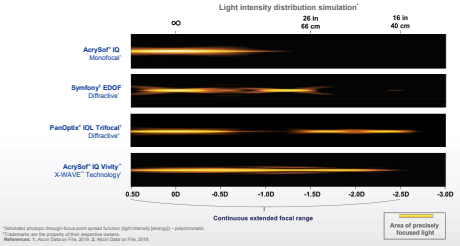
SMOOTH SURFACE TRANSITION ELEMENTS:
SIMULTANEOUSLY STRETCH AND SHIFT THE WAVEFRONT WITHOUT SPLITTING IT[1]

X-WAVE™ Technology Consists of 2 Smooth Surface Transition Elements



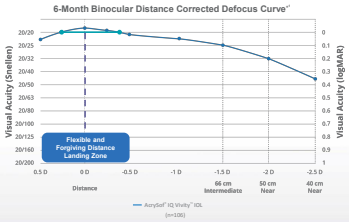
Reference: 1. Alcon Data on File, 2019.
The AcrySof® IQ Vivity™ IOL will be available in both BLF and UV-only at market launch.

NON-DIFFRACTIVE X-WAVE™ TECHNOLOGY:
CREATES A CONTINUOUS EXTENDED FOCAL RANGE



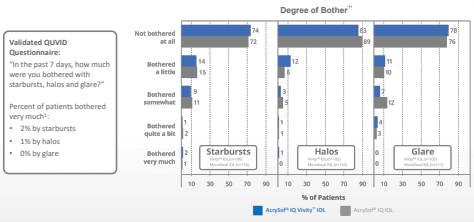
*Simulated photopic through-focus point spread function (light intensity [energy]) – polychromatic.
†Trademarks are the property of their respective owners.
References: 1. Alcon Data on File, 2019. 2. Alcon Data on File, 2019.

OUTSTANDING OVERALL PERFORMANCE:
DESIGNED TO PROVIDE A CONTINUOUS EXTENDED RANGE OF VISION



*For this clinical study, emmetropia was targeted for the lens. Slight hyperopic shift (≤ to 0.5 D) may impact uncorrected distance visual acuity, which may lead to decreased near vision.
Reference: 1. AcrySof® IQ Vivity™ Extended Vision IOL Directions for Use.

PATIENT-REPORTED VISUAL DISTURBANCES:
LOW LEVELS OF BOTHER SIMILAR TO MONOFOCAL[1]



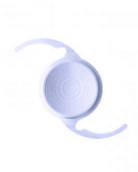
*Results from a prospective, randomized, parallel group, subject- and assessor-masked, multisite trial of 107 subjects bilaterally implanted with the AcrySof® IQ Vivity™ Extended Vision IOL and 113 with the AcrySof® IQ IOL with 6 months' follow-up.
†Assessed using QUVID questionnaire.
Reference: 1. AcrySof® IQ Vivity™ Extended Vision IOL Directions for Use.

J&J Vision – Tecnis Eyhance

- First lens[1] in the monofocal IOL category in Europe to deliver improved intermediate vision and 20/20* distance vision
- TECNIS Eyhance IOL offers the same well-established low incidence of halo, glare, or starburst as TECNIS® 1-piece IOLs
- FDA approved 2/2/21

J&J Vision – Tecnis Synergy

- Gives broad range of continuous vision[3] covering from distance to 33 cm**[4-6]
- Eliminates the visual gaps present in trifocal and other multifocal technology
- Continues to deliver superior performance in low-light conditions***[2]
- Violet-filtering technology demonstrates reduction in halo intensity for tasks like night driving,[7]



**Not FDA Approved

Trifocal IOL - PhysIOL

-
-
  add for N and +1.75D for intermediate
- Less glare and halos
- Designed to reduce the loss of light energy resulting from any diffractive system
- Diffractive anterior surface entirely convoluted
- Height of the diffractive step varied
- Distributes light to near, intermediate and distant foci adjusted according to the pupil aperture

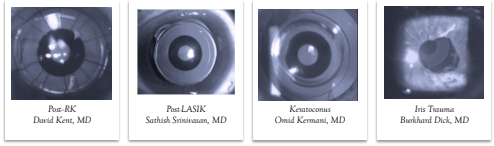
**Not FDA Approved

"Pinhole" IOL Design

- IOL Material
  - Single-piece hydrophobic acrylic
- Mask
  - PVDF & nano-particles of carbon
  - 1.36mm aperture
  - 3.23mm total diameter
  - 3200 microperforations
  - 5 microns thick

**Not FDA Approved

Presbyopia Correction No Longer Only for the Perfect Cornea!

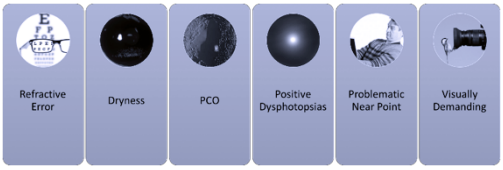


Postoperative Complications

- 1 day – High or low IOP
- 3-7 days – Endophthalmitis
- 2-3 weeks – Steroid Responder
- 3-4 weeks – Iritis/Uveitis
- 3-6 weeks – CME
- 1-3 months – Posterior capsule opacification

20/Unhappy

Causes of unhappiness



Woodward MA, Randleman JB, Stulting RD. Dissatisfaction after multifocal intraocular lens implantation. *surgery*. 2009;35(6):992-997. doi:10.1016/j.jcrs.2009.01.031.

Neuroadaptation of Multifocal IOLS

- Patients' expectations of time frame needed to adapt needs to be managed
  - These patients require more counseling post-op
  - Neuroadaptation can take as long as 6-12 months
  - About 10% never neuroadapt (will need IOL exchange)
  - No way of testing before surgery which patients will be able to adapt vs not
- Multifocal IOLs will induce more aberrations than monofocal IOLs

Take away: no YLC to be performed until rule out that IOL exchange is necessary

Refractive Enhancement: Laser Vision Correction (LVC)

-
- Wait at least 2-3 months after cataract surgery for wounds and LRIs to settle
- Nd:YAG posterior capsulotomy BEFORE LVC
  - **that was never happy**

Managing the Unexpected Outcome: Have an Algorithm to Identify the Issue

- Develop communication with your staff regarding dissatisfied patients
  - Encourage clinic techs to communicate patient satisfaction to you
  - Have work-up done before you see the patient
    - **MRx BCVA/Topo/OCT/Ocular surface testing**
  - Have a plan to fix the problem before you enter the room!

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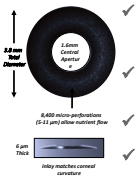
KAMRA® Inlay

First US approved corneal inlay; commercially available in 50 countries

Effective, Reliable and Safe Presbyopia Solution



- ✓ **Improves near vision with minimal impact to distance vision**
  - Achieves long-lasting results even as presbyopia progresses
- ✓ **Implanted into corneal pocket created with femtosecond laser**
  - Implanted monocularly into non-dominant eye
- ✓ **Highly biocompatible material**
  - Made from Polyvinylidene Fluoride (PVDF)
- ✓ **Removable via low-risk procedure with recovery of pre-inlay vision**

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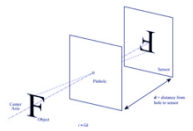
How It Works

- The inlay works like an aperture in a camera (opening)
- This small opening allows only focused images in the eye
- Only focused light rays to reach the retina
- Same principle used in camera lenses to increase depth-of-focus

Pinhole Principle: "Increased Depth of Focus"



Indications for Use

- Patient who is between 45 and 60 years old
- Cycloplegic refraction between +0.50 D and -0.75 D with less than or equal to 0.75 D of refractive cylinder
- Patient does not require glasses or contact lenses for clear distance vision
- Patient requires near correction of +1.00 D to +2.50 D of reading add

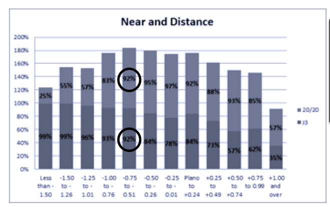
Inlay Patient- Exclusion Criteria

- Any ocular or systemic disease that is a contraindication for corneal refractive procedures including:
  - Keratoconus
  - Uncontrolled and/or severe dry eye
  - Cataracts
  - Macular degeneration
  - Corneal dystrophy or degeneration
  - Amblyopia or Strabismus
- Patients with unrealistic expectations
- Patients with psychological conditions

Post-op Exam

- Minimum follow-up:
  - 1 day
  - 1 week
  - 1, 3, 6 months
  - 1 year
- Patients should be ***seen more frequently*** if abnormal post-op findings are observed

Effectiveness of Post-op MRSE



92% of patients achieved ≥ to 20/20 UCDVA and J3 UCNVA when post-op MRSE = -0.50 to -0.75

Pharmacologic Treatments for Presbyopia Are Coming, With Miotic Drops Occupying the Majority of Development

Topical Drops in Development	Active Ingredient(s)	Mechanism of Action
Brimochol™ (Visus Therapeutics)	Carbachol + brimonidine tartrate	Carbachol: Miotic Brimonidine tartrate: Prevents pupil dilation, inhibits contraction of ciliary muscle, increases bioavailability of carbachol[1,2], prevents redness[3]
CSF-1 (Orasis)	Pilocarpine	Miotic
PRX-100/Liquid Vision (Presbyopia Therapies)	Aceclidine	Miotic
AGN 190584 (Allergan)	Pilocarpine	Miotic
MicroLine (Eyenovia)	Pilocarpine	Miotic
AcuStream™ (Kedalion)	Pilocarpine	Miotic
Nyxol® and Pilocarpine Combination Kit (Ocuphire)	Phentolamine mesylate and pilocarpine	Miotic (both pilocarpine and phentolamine mesylate products) Vasodilates small muscles (phentolamine mesylate product)[6]
True Vision Treatment® Contact lenses and Eye Drops Kit (Yolia Health)	Hyaluronidase and collagenase	Alters cornea [7]
UNR844 (Novartis)	Lipoic acid choline ester	Lens-softening agent
VP1-001 (Viewpoint Therapeutics)	Stabilizing alpha-crystallin molecule	Target's protein misfolding to restore native, functional shape[8]

- Miotic drops increase depth of field by inducing a pinhole effect
  - Low risk, highly effective and easily reversible compared to surgical alternatives
  - Miotic drops aren't without side effects - headache, brow ache, IOP fluctuations, myopic shift and hyperemia[4,5]
  - Single-agent cholinergic miotics likely to have more of an issue with these side effects than combination drops
- Lens softening topical agents intend to increase ability to accommodate with usage over time

1. *Ophthalmol Ther*
0078500 A1). 3. LUMIFY® Product Insert www.fda.gov accessed 9/24/2020. 4. Becker-Shaffer's Diagnosis and Therapy of the Glaucomas (Eighth Edition), 2009. 5. Korczyn et al. Effect of Pilocarpine on Intraocular Pressure in Normal Humans. *Ophthalmic Res.* 14:182-187 (1982).
6. Pepose. Phentolamine Mesylate Ophthalmic Solution Provides Long Lasting Pupil Modulation And Improves Visual Acuity, ARVO 2020 Abstract: #3364450.7 .Yolia Health. 8. Viewpoint Therapeutics ,February 2021

Patients Looking for Efficacy, Durability and Favorable Side Effect Profile

Thinking about the features of this potential new eye drop medication, which features are most appealing to you?

- **Efficacy** – restore functional near vision as well as current solution (glasses/contacts)
- **Duration** – lasting throughout a work day (minimum)
- **Side Effect Profile & Tolerability –** minimal brow ache/headache, minimal burning/stinging
- **Cosmesis** – eyes should be white and quiet

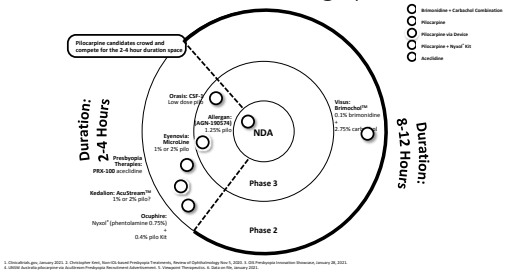
EFFECTIVE ...as reading glasses **94%**

LONG-LASTING ... at least 8 hours **96%**

COMFORTABLE ...mild/minimal side effects **83%**

Burke Healthcare Research April 2020, n = 1,000 presbyopes ages 40-80 years old

U.S. Presbyopia Miotic Drop Landscape is Crowded in the Short-acting Space



1. Clinicaltrials.gov, January 2021. 2. Christopher Kent, Non-IOL-based Presbyopia Treatments, Review of Ophthalmology Nov 7, 2020. 3. IDS Presbyopia Innovation Showcase, January 28, 2021. 4. UNSW Australia pilocarpine via AccuStream Presbyopia Recruitment Advertisement. 5. Vinegoni Therapeutics. 6. Data on file, January 2021.

Which Patients May Be the Best Candidates for Miotic Drops?

- Emmetropes
  - Least comfortable with vision correction surgery
- Post-LASIK emmetropes
  - Have already made significant investment to be glasses-free
  - If LASIK was performed prior to wavefront-guided procedures and aspheric optical zones, pupil constricting drops may also help to address higher order aberrations, glare and halo
- Hyperopes
  - Will improve vision at distance and near
- Pseudophakes
  - Monofocal IOL patients may opt to use drops instead of readers
  - Premium IOL patients may want additional near vision than their IOL provided

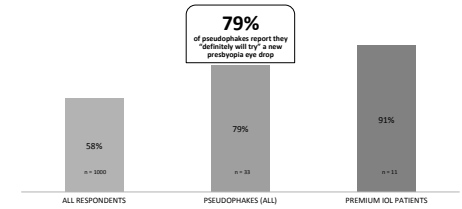
Contraindications

- High myopes
- Past history of retinal tears

Pseudophakes Very Interested in Trying a Presbyopia Drop – a Highly Motivated Patient Segment

If your eye doctor recommended it, how likely would you be to try this new eye drop to temporarily restore your near vision?

% OF PSEUDOPHAKES IN COMPARISON TO ALL RESPONDENTS WHO RESPONDED "DEFINITELY WILL TRY"



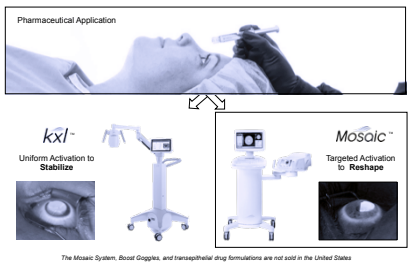
Burke Healthcare Research April 2020, n = 1,000 presbyopes ages 40-80 years old

What Do We Know about the Topical Presbyopia Market?

- The unmet need for a topical drop to improve near vision is significant
- Duration of action is important to patients and will likely lead to less frequent dosing
- Side effect profiles will vary based on active ingredient concentrations and differing MOAs
- Tolerability will be an important consideration – does it burn and sting?
- Cosmesis will factor in patients' receptivity to drops – will patients accept hyperemia to achieve NVA improvement?
- Exercise caution with patients who have compromised ocular surface, especially for drops with short duration of action

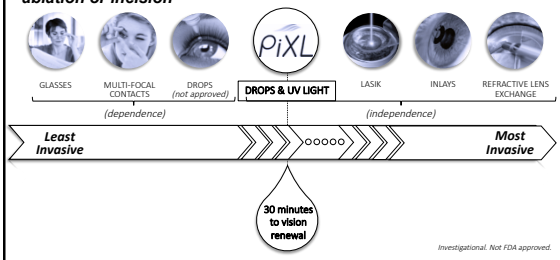
Avedro's Approach: Non-invasively Stabilizing and Reshaping the Cornea

Corneal Remodeling Technology



The Mosaic System, Boost Goggles, and transepithelial drug formulations are not sold in the United States

Corneal remodeling for non-invasive reshaping the cornea without ablation or incision

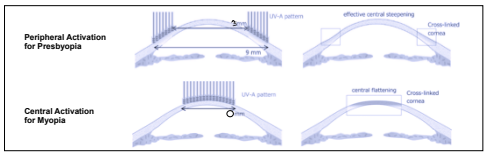


Investigational. Not FDA approved.

PiXL for Vision Improvement

Non-invasive corneal remodeling

Treatment Concept	Visual Target	Patient Experience
One time, non-invasive corneal remodeling treatment	Spectacle independence Binocular UNVA of J2 or better No halo or loss of CDVA	Non-invasive, simple procedure 1-2 day recovery Long-term stability of CXL

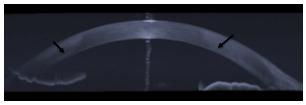


Investigational. Not FDA approved.

PiXL for Presbyopia

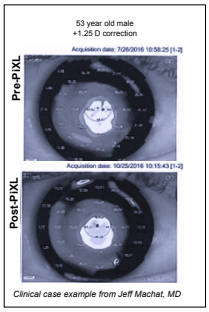
Spatially targeted, epithelium-on, accelerated cross-linking

More than 200 eyes treated internationally with PiXL to date



-
- corneal stromal demarcation line after epi-ON PiXL with oxygen

Investigational. Not FDA approved.



Clinical case example from Jeff Machat, MD

- presbyopia
- Filling a gap in refractive treatment options
- Drops, UV light and O_2
- Targeted corneal reshaping with long-term durability of cross-linking
- Likely advantageous for post operative cornea adjustability
- Early clinical results are promising
- **Multicenter Phase II Study in 2019**

PiXL

Mosaic System

Proprietary computer software and UVA beam forming technology

Boost Goggles

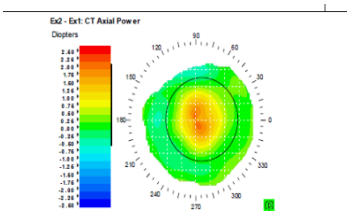
New Drug Formulations

Proprietary single-use drug formulations

Investigational. Not FDA approved.

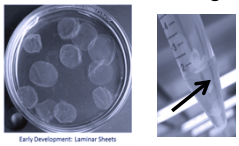
Allogenic Corneal Inlay (Allotex)
PEARL: PrEsbyopic Allogenic Refractive Lenticule

- ncreasing central corneal power to improve near vision



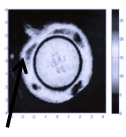
Excimer laser shaped corneal inlays

Scaling



Valuable use of gifted human tissue!

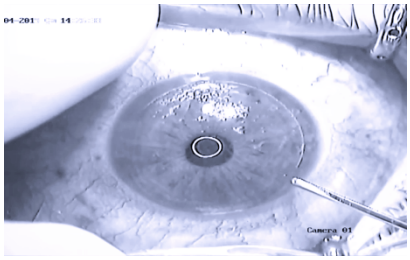
Predictability



Human tissue shaped with excimer laser precision.

www.allotex.com

Surgical Procedure (Aylin Kylic, MD)



European Multicenter Study: Interim data analysis (20 eyes)

	Preoperative	Post-op (last visit)
UCNVA of 20/40 or better (monocular)	0%	95%
Near Vision (binocular)	Gain: +17 letters (mean)	
Intermediate Vision (binocular)	Unchanged: +2 letters (mean)	
Distance Vision (binocular)	Unchanged: -2 letters (mean)	

*** last visit was 1 or 3 months after surgery

c/o Aylin Kylic, MD

The LIRIC Platform: Laser Induced Refractive Index Change for Refractive Error Correction

LIRIC: *a disruptive technology*

Poised to revolutionize:
- **refractive surgery**
- **cataract surgery**
- **contact lenses**

A revolutionary way to refine the optics of the eye

Cornea
- Minimally invasive
- No flap, epi on, no doping
- No nerve damage

IOL
- Post-implantation optical touch-up
- Monofocal to multifocal & vice-versa
- Correct residual refractive error

Contacts
- Enables diffractive multifocals for better presbyopia correction
- Thin lenses for all prescriptions
- Better oxygen transmissibility

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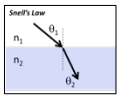
The LIRIC Platform

Low-Pulse Energy Femtosecond Laser

- **Refractive Index Modification**
  - Refractive error correction[1,2,3]
  - Presbyopia correction[4,5]

Refractive Index Bends Light



Air	1.00
Water	1.33
Cornea	1.39
Contact Lens	1.42
Glass	1.50

1. Gandara-Montano et al., Optical Materials Express, 2017
2. Gandara-Montano et al., Optical Materials Express, 2018
3. Zhelezniyak et al., ARVO 2018
4. Zhelezniyak et al., ARVO 2019
5. Butler et al., ARVO 2019

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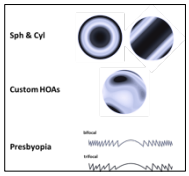
The LIRIC Platform

Low-Pulse Energy Femtosecond Laser

- **Refractive Index Modification**
  - Refractive error correction[1,2,3]
  - Presbyopia correction[4,5]



1. Gandara-Montano et al., Optical Materials Express, 2017
2. Gandara-Montano et al., Optical Materials Express, 2018
3. Zhelezniyak et al., ARVO 2018
4. Zhelezniyak et al., ARVO 2019
5. Butler et al., ARVO 2019

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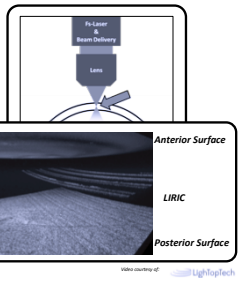
The LIRIC Platform

Low-Pulse Energy Femtosecond Laser

- **Refractive Index Modification**
  - Refractive error correction
  - Presbyopia correction
- **High Resolution Wavefronts**
  - Multiphoton process
  - Scanning µm-size laser focus
  - Repeat treatments: thin LIRIC layer, ~10 µm



LIRIC is embedded beneath the surface

Video courtesy of: LightTopTech

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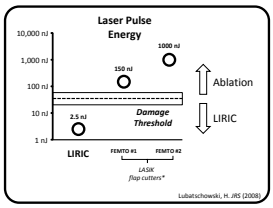
The LIRIC Platform

Low-Pulse Energy Femtosecond Laser

- **Refractive Index Modification**
  - Refractive error correction
  - Presbyopia correction
- **High Resolution Wavefronts**
  - Multiphoton process
  - Scanning µm-size laser focus
- **Below damage threshold**
  - No ablation
  - No tissue cutting
  - No flap required
  - Epi-on, no doping required



Lubatschowski, H. JRS (2008)

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Cornea:
Overcoming the limitations of laser refractive surgery

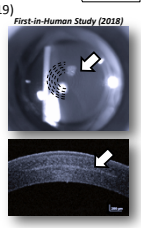
Cornea

Minimally invasive surgery
- No incision, no flap, no dopants (Zheleznyak et al., ARVO 2019)
- Less keratocyte cell death (Wozniak et al., Exp Eye Res 2018)

Potentially less dry eye
- No corneal nerve damage (Wozniak et al., ARVO 2019)

Maintain tissue integrity
- Tissue sparing, no ablation

High optical quality
- High precision wavefront induction



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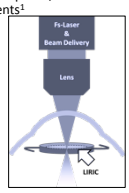
IOL:
Overcoming the limitations of cataract surgery

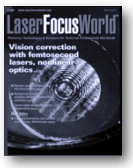
IOL

Residual Refractive Error
- Standard cataract surgery: ±0.5 D sphere, >1 D astigmatism in 45% of patients[1]
- LIRIC customized correction (0.05 D resolution)[2,3]



Monofocal to Multifocal

Multifocal to Monofocal



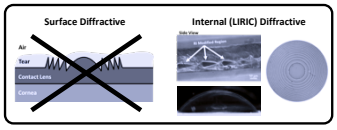
1. Behndig et al., JCRS 2012
2. Gandara-Montano et al., OMEX 2018
3. Pepose et al., AAO 2017

74

Contact Lens:
Overcoming limitations of traditional contacts

Contacts

Superior Presbyopia Correction
- Internal diffractive multifocals superior to refractive multifocals



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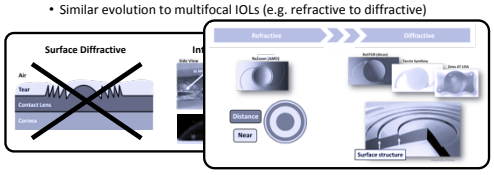
Contact Lens:
Overcoming limitations of traditional contacts

Contacts

Superior Presbyopia Correction
- Internal diffractive multifocals superior to refractive multifocals
- Similar evolution to multifocal IOLs (e.g. refractive to diffractive)



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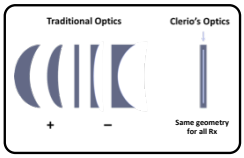
Contact Lens:
Overcoming limitations of traditional contacts

Contacts

Superior Presbyopia Correction
- Internal diffractive multifocals superior to refractive multifocals
- Similar evolution to multifocal IOLs (e.g. refractive to diffractive)

Higher Oxygen Transmissibility
- Thin lenses for all Rx



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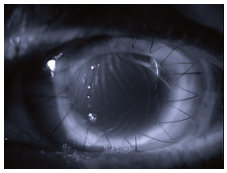
Updates on Modern Day Corneal Surgery

Common Corneal Procedures

- Corneal crosslinking
- Penetrating keratoplasty
- Descemet's stripping endothelial keratoplasty
- Pterygium surgery
- Superficial keratectomy



Watch Out for Keratoconus!

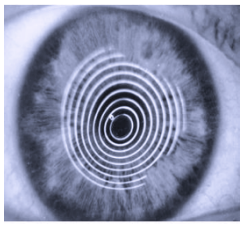
8 Potential Signs & Symptoms

Typically onset occurs in teenage years or early twenties

- **Look out for warning signs in medical history**
  - History of eye rubbing
  - Family & genetic predispositions
- **Look out for visual complaints**
  - Blurred vision
  - Distortion of images
- **Look out for refractive anomalies**
  - Distortion of mires on keratometry
  - Error messages on autorefractors
  - Unsatisfactory attempts at vision correction & progressive loss of UCVA & BCVA
  - Increasing astigmatism

Diagnostic Imaging

- Irregular Placido (egg-shaped) Topography



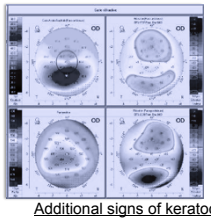
Early signs of keratoconus may include

- *astigmatism*
- *Asymmetric or truncated bow-tie*

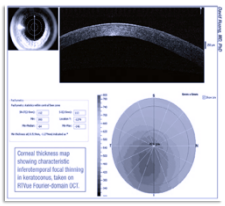
[4] V.S. Rabinowitz. Keratoconus. Survey of Ophthalmology Vol 42. Num 4. Jan-Feb 1998.

Diagnostic Imaging

Irregular Topography/Tomography



Focal thinning on OCTs[1]



Additional signs of keratoconus may include

- Astigmatism variance between eyes
- Stromal and epithelial thickness changes
- Posterior elevation changes
- Wavefront aberrations
- Topographic changes
  - Inferior steepening
  - Irregularity indices

[1]https://www.reviewofophthalmology.com/article/making-the-most-of-anterior-segment-oct.

Corneal Crosslinking

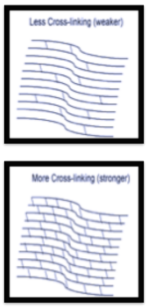
- UV light and photosensitizer to strengthen chemical bonds in the cornea
  - Oxidative deamination reaction with ends chains of collagen
- FDA Approved in the US 2016
  - Epi-off
- Indicated to help slow progression of:
  - Keratoconus
  - PMD
  - Terrien Marginal Degeneration
  - Post-refractive surgery ectasia

Contraindications

- Corneal thickness <400um (epi off)
- Prior herpetic infection
- Concurrent infection
- Severe corneal scarring or opacification
- History of poor epithelial wound healing
- Severe ocular surface disease
- Autoimmune disorders

Mechanism of Action

- Corneal collagen cross-linking combines the use of and **(vitamin B2) drops**
- The absorption of UVA by riboflavin generates radical riboflavin and singlet oxygen to form cross-links[1]
- **Corneal Cross-Linking**:
  - Creates new corneal collagen cross-links
  - Results in a shortening and thickening of the collagen fibrils
  - Leads to the stiffening of the cornea[2]



[1] Kamaev P, Friedman MD, Sherr E, Muller D. Photochemical kinetics of corneal cross-linking with riboflavin. Invest Ophthalmol Vis Sci. 2012;53:2360–7.
[2] Beshtawi IM, O'Donnell C, Radhakrishnan H. Biomechanical properties of corneal tissue after ultraviolet-A-riboflavin crosslinking. J Cataract Refract Surg. 2013;39(3):451–62.

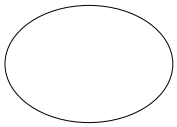
Keys to Patient Counseling: Discuss Treatment Goals

Aim of CXL is to halt or slow disease progression

Cross-Linking is <u>not</u> a refractive procedure

Post-op evaluation for visual correction will be necessary

Follow-up Care Landmarks

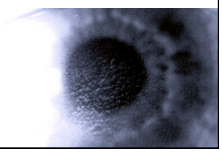


Due to Zero Global period, those may be billable to insurance for follow up when medically indicated

VISIT	PLAN
Day 1 to 1 Week	• Topical antibiotic, steroid • Frequent lubricants • No eye rubbing • Remove BCL once epithelium heals
Month 1	• OCT Imaging • Tomography/Topography • Vision assessment • Contact lens refitting evaluation
Month 3, 6, 12 *(Follow ups potentially performed and billed by diagnosing physician depending on practice preference)*	• Continued evaluation utilizing tomography/ topography • Vision assessment

CXL Complications

- Endothelial cell damage
  - <400um thickness
- Persistent epithelial defects (epi off)
  - Mechanical, CL preservatives, topical medication
  - Haze
- Scarring
- Infectious keratitis
  - Fungi, bacteria, HSV,
  - Acanthamoeba
  - HSV vs UV light



Long-term maintenance

- Close monitoring immediately after CXL
  - Every 3 months with pachymetry, MRX and corneal topography
  - Then decrease to yearly to monitor for any progression
- Counseling patient that mechanical rubbing of the eye can cause it to progress
  - Treat allergies
  - Treat DED
  - Treat Blepharitis/MGD

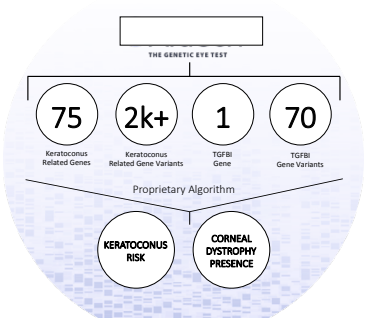
GENETIC DATA CAN HELP US...

Perform the right refractive surgery procedure on the right patient.

Identify the risk of keratoconus and presence of corneal dystrophies.

Supplement diagnostic data and environmental factors with genetic information to diagnose suspected and asymptomatic patients early

Confidently make decisions about patient management and treatment



WHEN I ORDER AN **Genetic testing…**

Ocular Diagnostic Assessment

	1 Family History	2 Irregular Topography				3 Refractive Concerns			4 Refractive Concerns				
	Family Members Suspected for confirmed KC	**Red Flag** corneal concerns, topography or anything that causes me to pause	**Against-the-rule** or oblique astigmatism in your younger patients	**Suspicious** or subtle astigmatism irregularity, such as smirkers bowtiers	**Pachymetry** Thin pachymetry	**High** Or progressive myopia or astigmatism	**Steep** Corneal curvature	**Suspicious** Pre-refractive surgery patient or post-LASIK ectasia	**Young** Laser vision correction candidates	**RSB** Borderline residual stromal bed measurements	**Corneal Dystrophy** Undetected, suspected or family history of corneal dystrophy	**LASIK vs PRK** When deciding between the two options
For Early Diagnosis & Management of Keratoconus (KC)	○	○	○	○	○	○	○					
For Corneal Crosslinking (CXL) Decisions		○	○	○	○	○	○	○				
For LASTIK / PRK / Refractive Surgery Decisions		○	○	○	○	○	○	○	○	○	○	○

Patient Case Study –

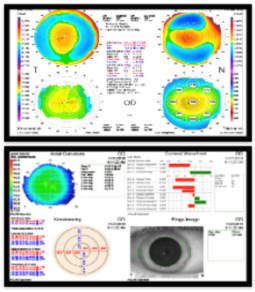
Refractive Evaluation

Patient Profile

- 29 year old AA male patient
- Unable to wear SCL
- Glasses Rx stable for past years
- PMHx: unremarkable
- MRX: OD -3.00 + 0.50 x 164 OS -3.00 + 0.25 x 178
- CCT: 535/551 microns

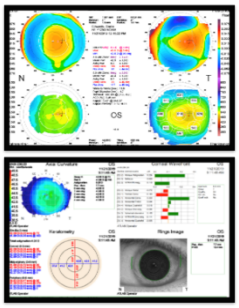
Patient Case Study

OD

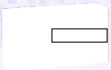


Patient Case Study

OS

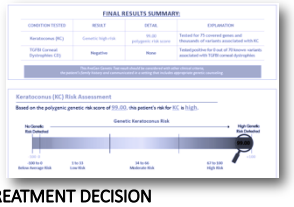


What Does Genetic testing Tell Us



WITH Genetic testing…

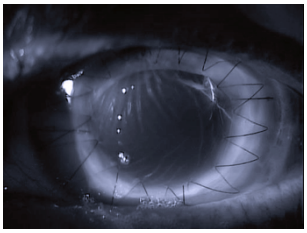
- Understand the right treatment plan
- Patient demonstrated risk score of **99** indicating a **HIGH** risk for KC

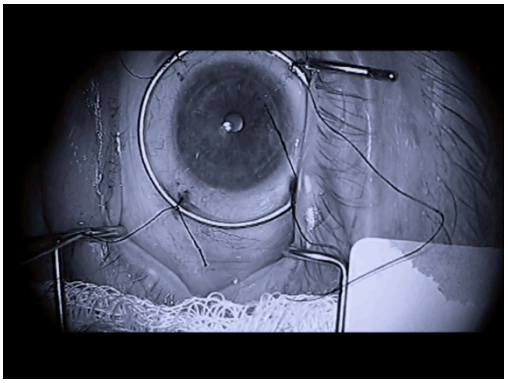


TREATMENT DECISION

- Deferred LASIK / PRK , patient can consider ICL surgery ou

Corneal Transplant



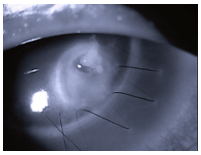


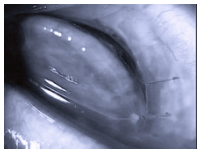
What to expect PK

- Day 1
  - Moderate to severe stromal/corneal edema
  - AC 1-2+ cell and pigment
  - Poor vision and pain
- Week 1
  - Moderate corneal edema may still be present
  - Vision is improved but still moderately decreased
  - AC some inflammation present (tr-1+ cell)
- Month 1
  - Most corneal edema should be resolved at this time
  - Refraction/Pachymetry/Atlas to monitor
  - AC is quiet
- Month 6
  - Stabilization
  - Select suture removal to decrease induced astigmatism

Complications of Penetrating Keratoplasty

- Long-term complications
  - Glaucoma
  - Microbial keratitis
  - Suture-related problems
  - Wound dehiscence
  - Immunologic graft rejection
  - Late endothelial failure
  - Graft failure
- Refractive error, astigmatism





Long-term maintenance

- Long term topical steroid to decrease rejection rate
- Some patients may require oral antivirals if corneal transplant is related to scaring from prior HSV
- Repeat PK may be needed after approximately 20 years

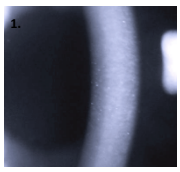
Descemet's Stripping Endothelial Keratoplasty (DSEK)

- Sutureless transplant of the posterior cornea
- Replaces diseased portion of cornea with donor graft
- Donor tissue obtained by
  - Manual dissection
  - Microkeratome dissection
  - Femtosecond laser

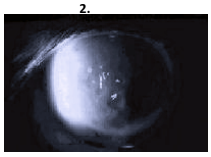
1. Photos accessed from http://www.moria-surgical.com/ on 8/26/11
2. Photos accessed from http://www.alcon.com/en/alcon-products/refractive-surgery.aspx

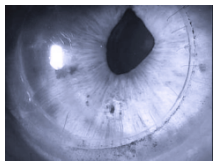
Indications

1.



2.

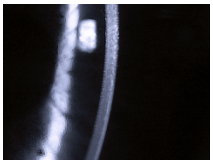




1. http://emedicine.medscape.com/article/1193218-overview
2. http://webeye.ophth.uiowa.edu/eyeforum/cases/case5.htm

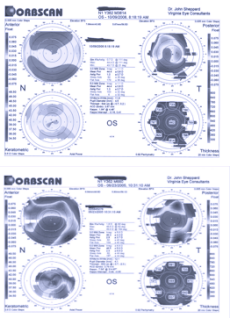
DSEK/DSAEK Exclusion Criteria

- Exclusion
  - Corneal scarring
  - Aphakic
  - Iris loss / atrophy



Advantages of DSEK/DMEK vs. PK

- Sutures
- Visual recovery
- Astigmatism / ametropia
- Epithelial complications
- Corneal allograft rejection
- Wound strength
- Globe stability
- Length of surgery
- Intraoperative complications
- Post op visits

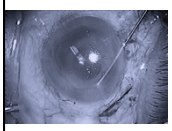


DSEK, PK Yield Similar Graft Survival

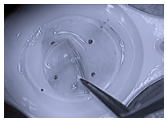
Price et al. Ophthalmology. 2011;118(4):725-729

- Retrospective, interventional case series
- DSEK graft survival rates
  - 95% for Fuchs
  - 76% for PBK/ABK
- PK graft survival rates
  - 93% for Fuchs
  - 73% for PBK/ABK
- Endothelial cell loss at 5 years
  - 53% in DSEK
  - 70% in PK

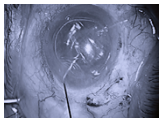
DSEK Procedure



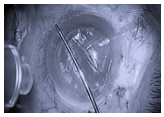
Incision / Stripping / Removal



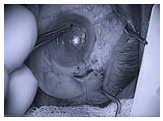
Donor Prep



Centration

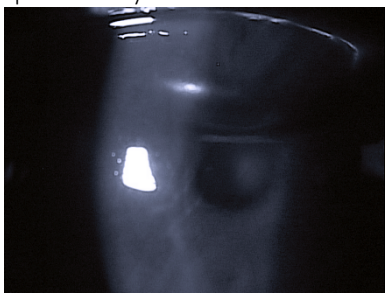


Removal of Fluid



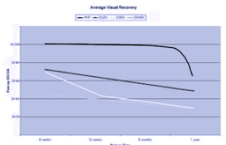
Closure of wound

Postoperative Day One



DSEK Average Visual Recovery

- 1 Day: 20/400
- 1 Week: 20/70
- 1 Month: 20/40
- 3 Months: 20/30
- 6 Months: 20/25
- 1 Year: 20/25-20/20



Dr. Gorovoy Study - Results presented during the AAO 2006 - Las Vegas

Terry and Shamie. Endothelial Keratoplasty. Retrieved from http://www.dlek-dsek.com/dsekprocedure.htm on 6/20/08.

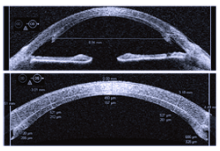
DMEK

- Graft of Descemet's membrane and endothelium only
- Better optical outcome of 20/25 or 20/20
- Difficult to manipulate
- Early graft dislocation risk
- Decreased risk of rejection

DMEK

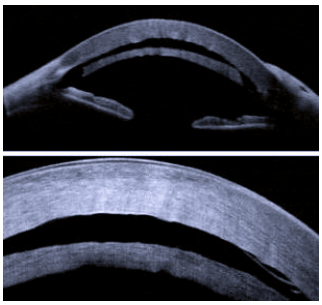
DSEK/DMEK Complications

- Caused by any of the following
  - Graft-recipient interface
  - Fragile graft tissue
  - Graft location
  - Glaucoma
  - Infection
  - CME
  - Retinal detachment



Miller, J. Accessed from http://www.revoptom.com/content/d/technology/c/16179/

DSEK Gone Wrong



Long-term Maintenance DMEK and DSEK

- Long term topical steroid
  - Helps decrease rejection rate
  - Steroid Loteprednol, prednisolone acetate, FML 1 gtt QD typically
- Unknown length of graft viability
  - No long term data since started approx 2003
  - In theory surpass PK ~20 years
- 5 year Graft survival similar at 93%[1]

1. Price DA, Kelley M, Price FW Jr, Price MO. Five-Year Graft Survival of Descemet Membrane Endothelial Keratoplasty (EK) versus Descemet Stripping EK and the Effect of Donor Sex Matching. Ophthalmology. 2018 Oct;125(10):1508-1514. doi: 10.1016/j.ophtha.2018.03.050. Epub 2018 May 3. PMID:

Limbal Stem Cell Deficiency

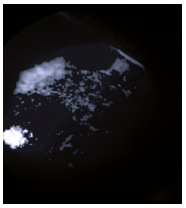
- When limbal stem cells begin to struggle and poorly function, the epithelial cell layer and its reproduction becomes compromised
- Loss or deficiency of stem cells in the limbus which are vital for re-population of the corneal epithelium and to the barrier function of the limbus
- Once limbal stem cells are damaged the epithelium will be replaced by conjunctival goblet cells

LSCD Causes

- Acquired
  - Trauma
  - Contact lenses
- Inflammatory
  - DED
  - Allergy
  - Neurotrophic keratopathy
- Autoimmune
  - Sjogrens Syndrome
  - Stevens Johnson syndrome
  - Mucous membrane pemphigoid
- Congenital
  - Aniridia
  - Autoimmune Polyglandular Syndrome
  - Keratitis, Icthyosis, and Deafness Syndrome

Signs and Symptoms

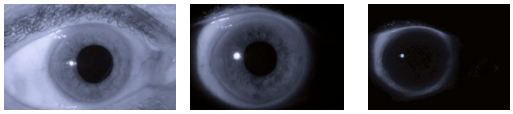
- Varying degree of ocular signs depending on severity and level of corneal conjunctivalization
- Symptoms
  - Decreased vision
  - Photophobia
  - Tearing
  - Blepharospasm
  - Recurrent pain



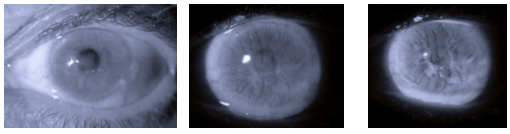
Severe LSCD

- Conjunctivalization
  - Corneal surface stains abnormally because the conjunctival epithelium is more permeable to the stain than true corneal epithelium
- More prone to recurrent or non-healing epithelial defects
- Stromal scarring or melting
  - Expect more pain and vision loss

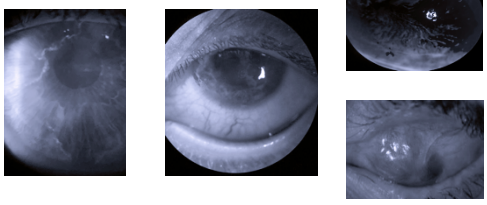
NORMAL EYE



TOTAL LSCD



Conjunctivalization



Non-Surgical Treatment

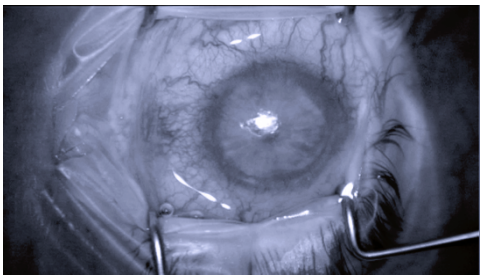
- Remove traumatic or toxic insults that may be the cause
- Discontinue contact lens wear
  - Possible refit in scleral
  - Bandage CL?
- Discontinue or switch topical medications
  - Glaucoma medications
  - Preservative sensitivity

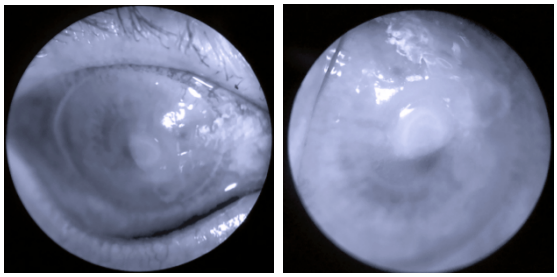
Non-Surgical Treatment

- Treating underlying systemic causes
  - Autoimmune control
- Improve tear film and control inflammation
  - Vitamin A ointment QHS
  - Topical steroids
    - Compounded Preservative Free option
  - Topical cyclosporine
  - Preservative free AT
  - Punctal Plugs

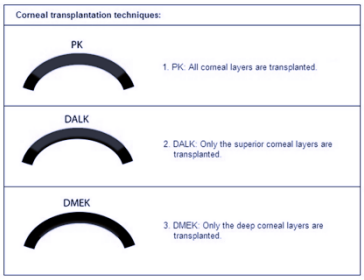
Non-Surgical Treatment

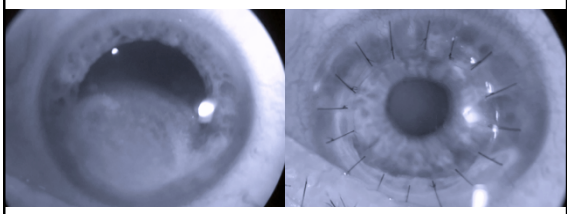
- Amniotic membrane
  - Dehydrated vs cryopreserved
- Amniotic membrane drops
  - Can be costly and not covered by insurance currently
- Serum Tears
  - Can be costly and inconvenient
- Cenegermin
  - Neurotrophic keratitis





DALK (deep anterior lamellar keratoplasty)





Pre/Post Example of Big Bubble DALK

Post-Operative Care

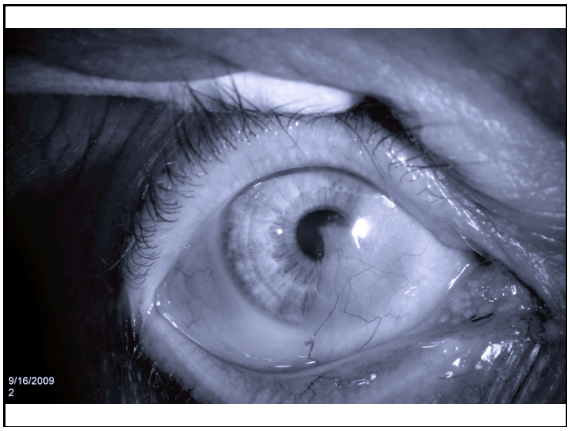
- Moxifloxacin QID OD x 1 week and Difluprednate starting at QID OD and tapered down to Loteprednol QHS OD for maintenance
- Several corneal sutures removed after 6-9 months
- Cataract extraction OD
- Final BCVA 20/25 OD

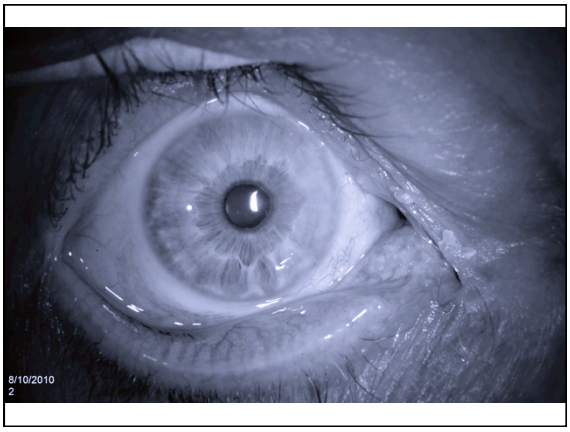
Pterygium

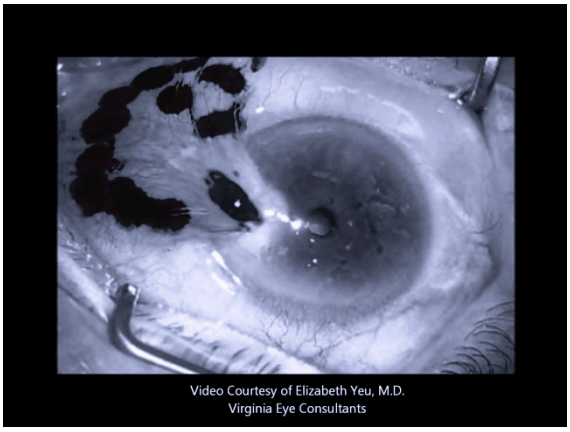
- "wing" like ocular surface lesion originating from limbal conjunctiva within the palpebral fissure progressing to the cornea
  - Nasal and temporal
- More common in people with history of increased UV exposure
  - Males>females
- Typically asymptomatic
  - Induced astigmatism

Treatment

- Non Surgical
  - Treat the ocular inflammatory response
    - Cyclosporin
    - Lifitegrast
    - Topical steroids
    - Artificial tears
- Surgical
  - Encroaching on visual axis
  - Preparing for cataract surgery
  - Significant induced astigmatism







What to expect after Sx

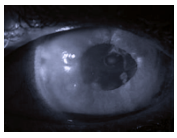
- Day 1
  - Epithelial defect
  - Conjunctival injection, check wound site
- Week 1
  - Epithelial defect healed with haze
  - Conjunctiva check for secure would site
    - Monitor for wound dehiscence
- Month 1
  - Haze resolution
  - Conjunctival stabilization

Long term treatment

- Control UV exposure
- Control dryness and inflammation
  - Cyclosporine
  - Lifitigrast
  - Artificial tears
  - Topical steroids
  - Punctal plugs
- Will help to control reoccurrence

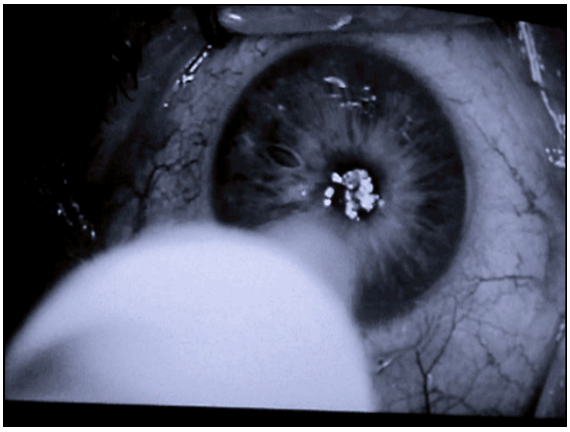
Lamellar keratoplasty

- Indications:
  - ABMD
  - Salzmanns
  - Band Keratopathy
  - RCE
  - Corneal scars



Lamellar Keratoplasty

- Corneal epithelium is removed down to Bowman's layer
- Can be performed in slit lamp or operating room using Weck-cel sponge or scarifier blade, and cleaned up with diamond burr
  - After removal surface is polished with cellulose sponge, antibiotics, and THBL placed



Long Term Treatment

- After lam K for RCE
  - Maintain THBL for 3 months
  - Oral Doxycycline
  - Topical Antibiotics
  - Topical Steroids
  - Vitamin C
- Control of ocular surface disease

Comanagement Pearls

- Opportunity to provide cutting edge technology
- Importance of your recommendation
- Patient education is critical!

Comanagement Pearls

- Identify potential causes of surgical complications
- Educate your patients your role within medical eye care
- *patients. Comfort and quality of vision is the key!*

Thank you!!