Large-Diameter DALK
You Won't Believe Your Eyes!

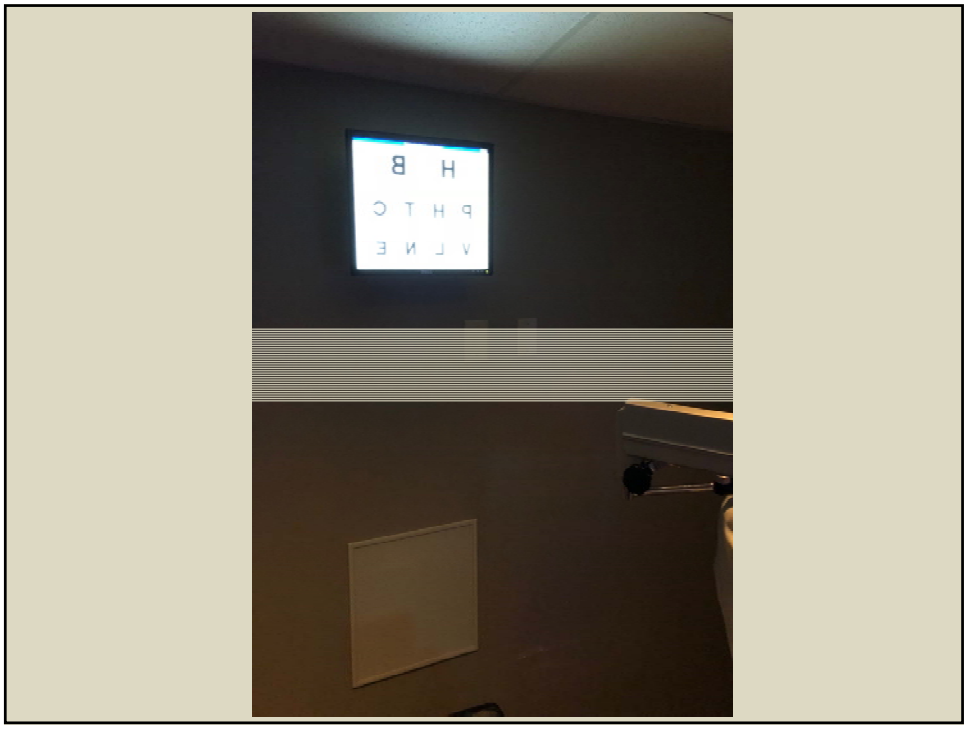
Richard Erdey, MD
Erdey Searcy Eye Group

Change Corneal Shape: Methods

- Slice
- Dice
- Fillet
- Ablate
- Heat
- Stiffen
- Suture
- Implants/Inlays
- Transplant

- Vertical: RK /AK (1980)/Femtosecond Laser
- Smile (2016)
- *Horizontal: Microkeratome/Crescent knife*
- *PRK/LASIK* (1995)
- Conductive Keratoplasty (2004) Holmium Laser (2000)
- ***Collagen Cross Linking (2016)***
- Compression with 9-0, 10-0 nylon or prolene sutures
- ***Intacs***, (1998) Kamra (2015)/Raindrop (2016)
- Penetrating keratoplasty (PK) (1905)

DSEK (2005)/DMEK (2011)
Deep Anterior Lamellar Keratoplasty (DALK) (1960)



What is 20/20 Vision?

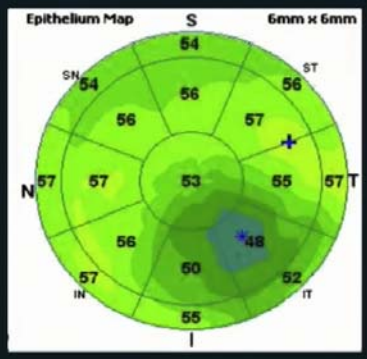
- All of the following represent 20/20 vision

20/20 20/20

20/20 20/20

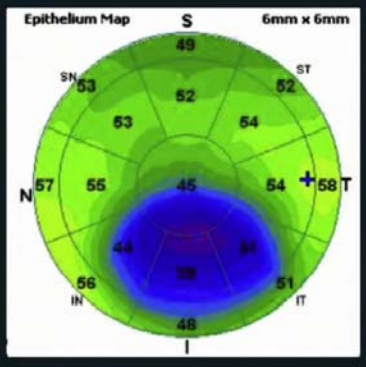
Epithelial Mapping: Keratoconus

Epithelial Mapping: Keratoconus

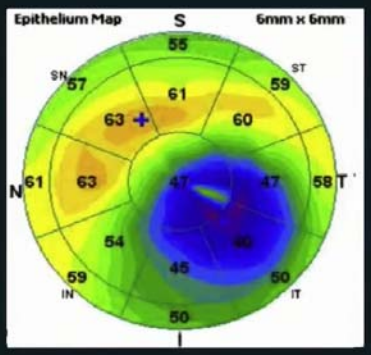


Corneal Crosslinking

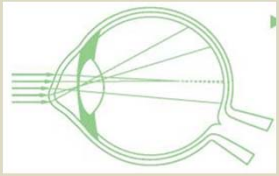
Epithelial Mapping: Keratoconus

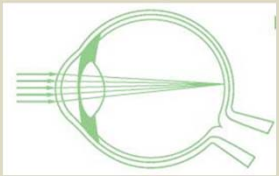


Epithelial Mapping: Keratoconus

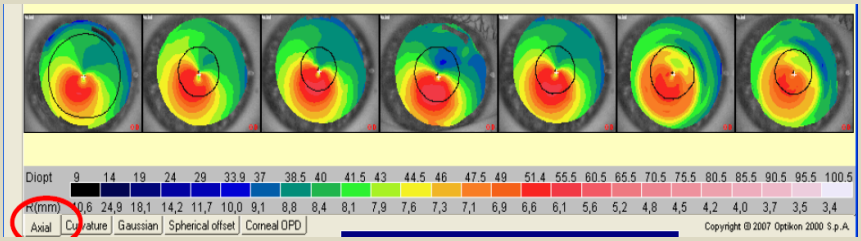


Corneal Cross-linking
Keratoconus / LASIK ectasia





Early results: stops progression
3-5 yrs (and beyond?) ave K's 1 D flatter
MOVING TARGET?



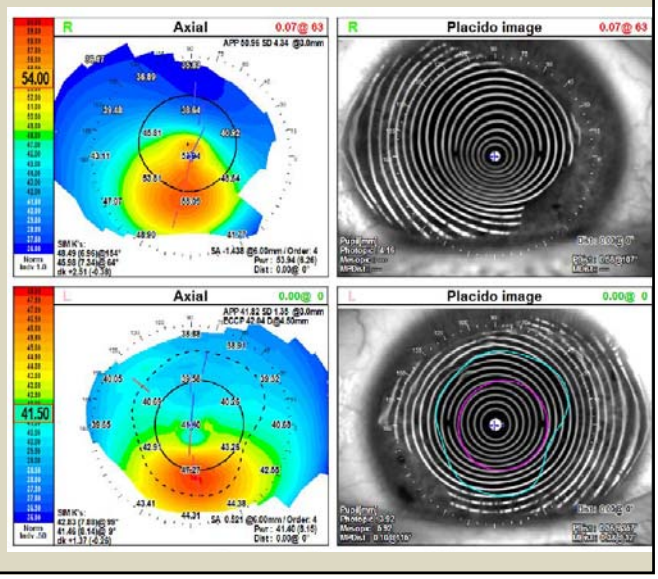
Corneal Cross-linking:
HOW LONG UNTIL I SEE BETTER?

- Painful
- Delayed re-epithelialization
- Risk of limbal stem cell deficiency
- Central scarring
- Unrealistic expectations

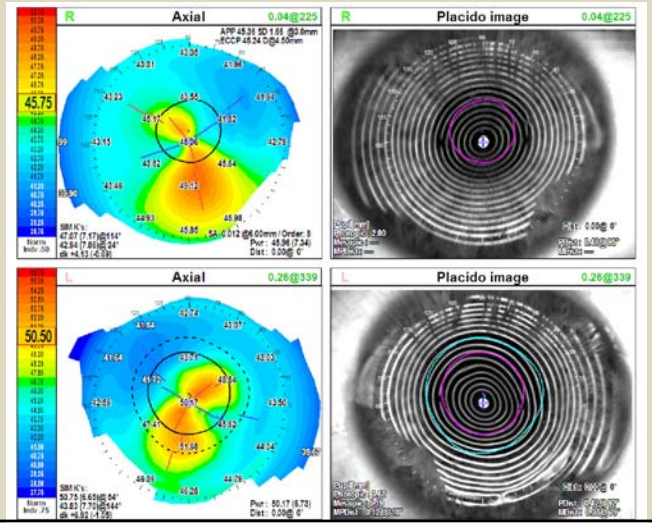
- 32 yo M CXL OU 2/2021 (performed elsewhere)

-19.0+2.75x15 20/80

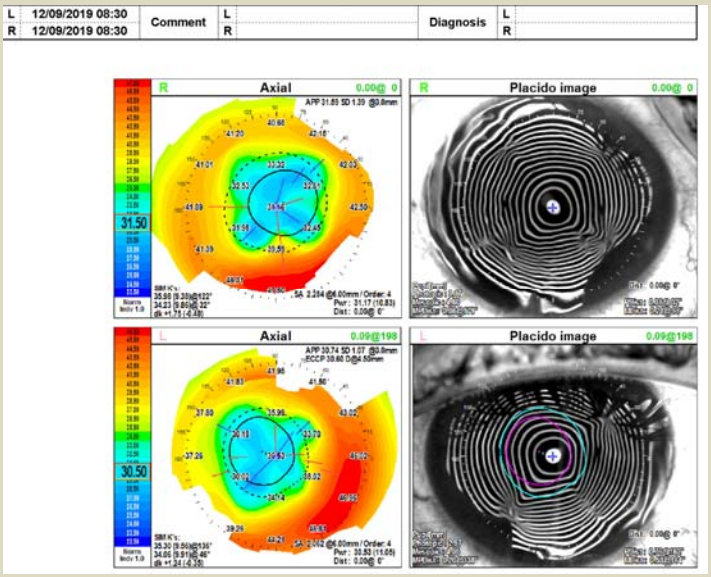
-3.25+1.50x142 20/20



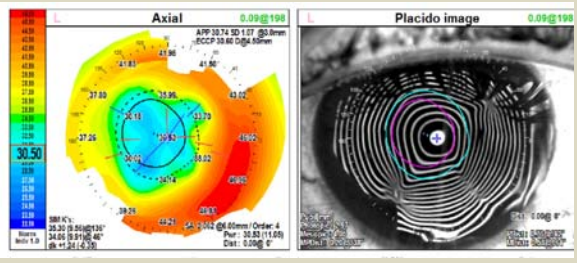
Referrred 3 mos after crosslinking OS (elsewhere)
LASIK OU 2008 -3.0 " vision OK 4 yrs" ectasia
OD: -2.50+2.0x165 20/20
OS: Unable: 20/150
"I still cannot see out of my left eye"



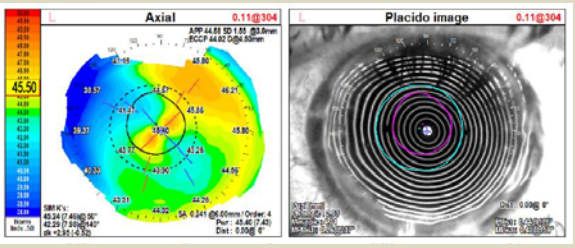
Case 5: 63 yo RK ectasia, irregular astigmatism, chronic diurnal fluctuation OU
"no improvement" after crosslinking (OS) 2013 and cataract surgery 2015 (OU)



Case 5: OS:
Pre-op DALK comparison
vs. 1.5 years after DALK, running suture out x 10 months

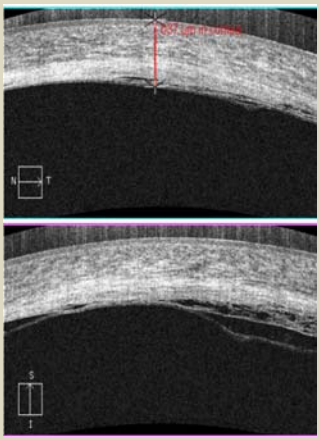


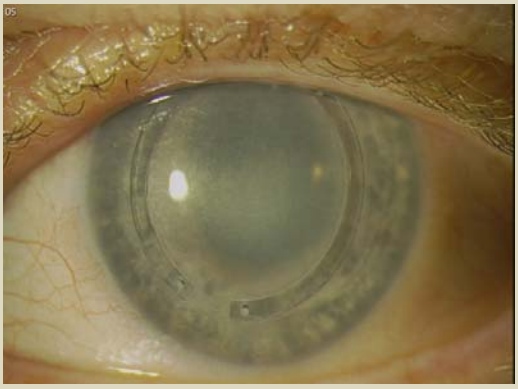
OS: Pre-op DALK 25yrs after RK
cataract / high power IOL



OS:1.5 yrs after DALK
7 mos after IOL exchange
UCVA 20/30
-0.5+0.5x008 20/20 add 2.50 J1

53 yo 2 days after Cross linking and AC air





Corneal Cross Linking – April 2016 US FDA approved: Progressive Keratoconus

- Feb 2015 FDA advisory panel “cautious nod”
- Narrowly voted to approve riboflavin (Photrexa – Avedro) and Photrexa Viscous (with dextran) based on 12 mo data
- Indications: Keratoconus
- lasik induced ectasia: Not approved.
- Long term efficacy data >12mos required.

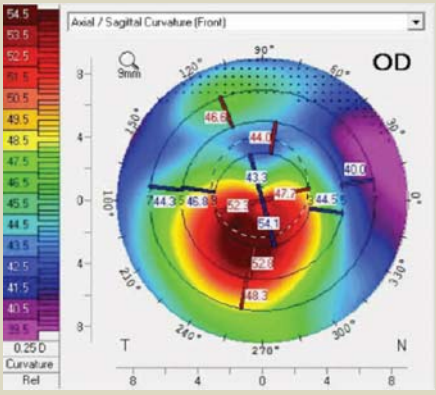
Summary
Cross Linking – Indications:

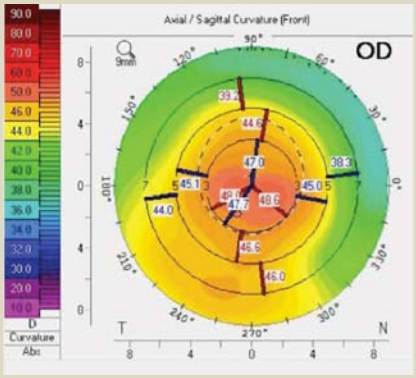
- Consider with mild – moderate (maybe??) keratoconus with documented progression

Warped Cornea:
Procedures

- Is Cornea Cross-linking with or without topographic guided PRK an appropriate option for moderate-advanced cases?

Cornea transplant or x-linking/Topoguided PRK?





How long will it take me to see? How long will it last?

Combined X-linking/ Topo-PRK?

American Journal of Ophthalmology Case Reports
Volume 23, September 2021, 101120

Severe long-term progressive corneal remodeling after bilateral simultaneous prophylactic crosslinking and topography-guided surface ablation with mitomycin

Juan Carlos Abad a ... Renato Ambrosio g

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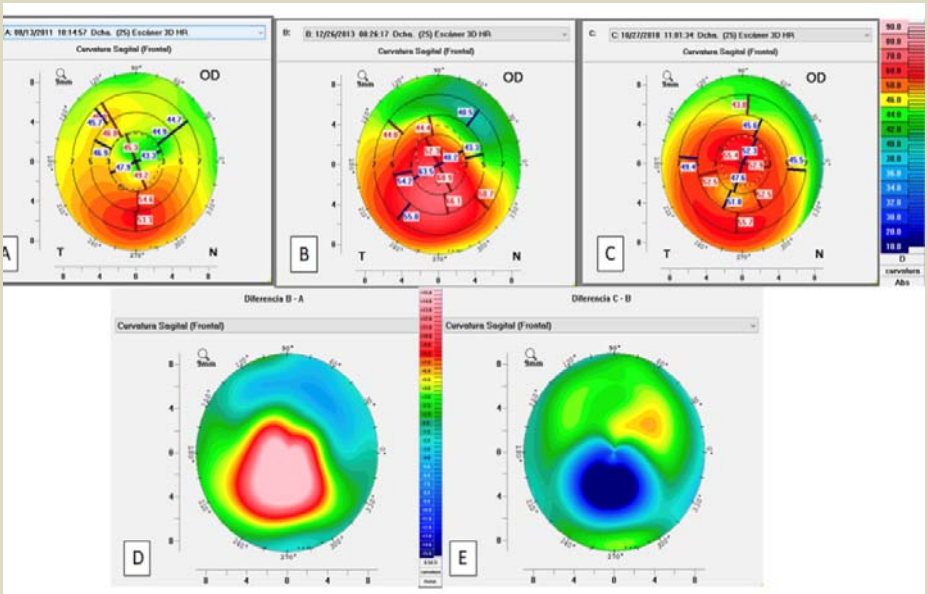
https://doi.org/10.1016/j.ajoc.2021.101120

Abstract

To report a case of a 20-year-old woman who developed massive and progressive corneal remo



ial Schleimpflug images of the right eye
tive corneal topography showing a typical "crab claw" pattern. B. One-and-a-half-year postoperative corneal topography showing marked corneal steepening. C. Six-year postoperative corneal topog
rked corneal deformation. D. Difference map B *minus* A showing close to 20 diopters of corneal steepening. E. Difference map C *minus* B showing spontaneous focal corneal flattening.

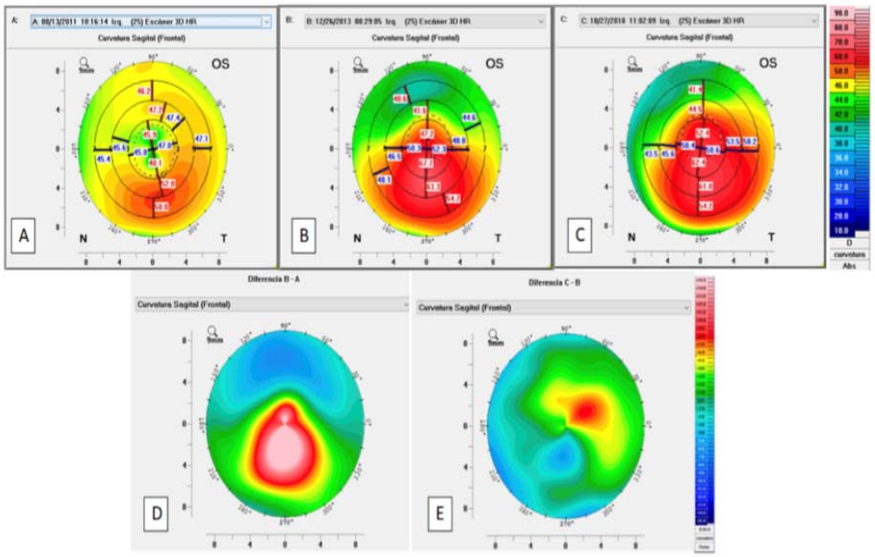


Fig. 2. Serial Schleimpflug images of the left eye
A. Preoperative corneal topography showing a typical "crab claw" pattern. B. One-and-a-half-year postoperative corneal topography showing marked corneal steepening. C. Six-year postoperative corneal topography showing marked corneal deformation. D. Difference map B *minus* A showing close to 20 diopters of corneal steepening. E. Difference map C *minus* B showing spontaneous focal corneal flattening.

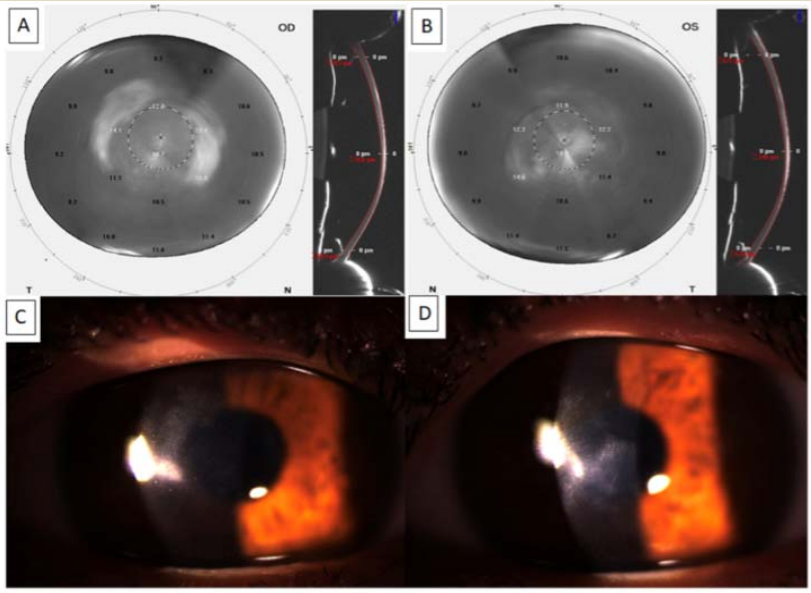


Fig. 3. Postoperative Scheimpflug corneal densitometry
A. Right eye. Note the full-thickness corneal sÉrring shown in the en-face image as the red line is moved all the way to the endothelium (354 μm) in the tangential insert. B. Left eye. Note the full-thickness corneal scarring shown in the en-face image as the red line is moved all the way to the endothelium in the tangential black and white insert. C. Corresponding slit-lamp microphotograph of the right eye showing patchy stromal haze. D. Corresponding slit-lamp microphotograph of the left eye with similar but more central findings. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Corneal Transplantation Indications:

- Keratoconus/Pellucid Marginal Degeneration
- Lasik/RK induced ectasia
- Cornea scars
- Cornea dystrophy
- Infectious Keratitis
- Cornea Melt

Warped Cornea/Scars/Melts: Procedures

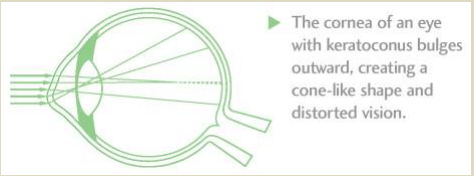
- Deep Anterior Lamellar Keratoplasty (DALK) (large diameter 9-10mm) “trained” with a running 10-0 nylon suture adjusted under an intraoperative keratometer
- `Penetrating Keratoplasty (PK) (7.5-8.25mm)

Questions: PK vs DALK?

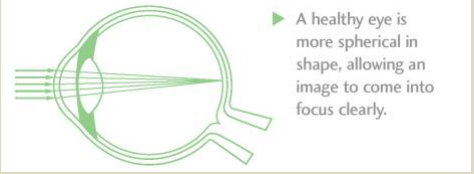
- Safe?
- Predictable?
- Adjustable?
- Reversible?
- How good are the optics?
- Stability – LONG TERM?
- “How long does it take until I can see?”

Keratoconus Goal of Surgery:

-Make eye refractable with glasses.
-Clear visual axis of scarring, if present.
-Stop progression

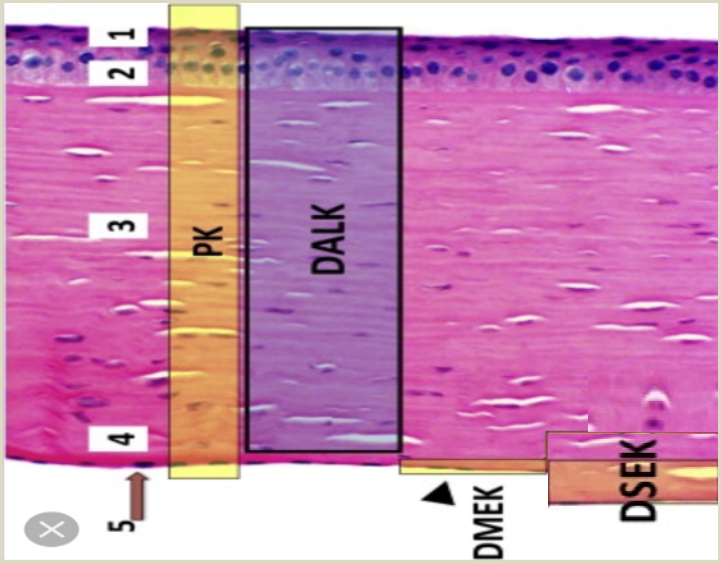


The cornea of an eye with keratoconus bulges outward, creating a cone-like shape and distorted vision.

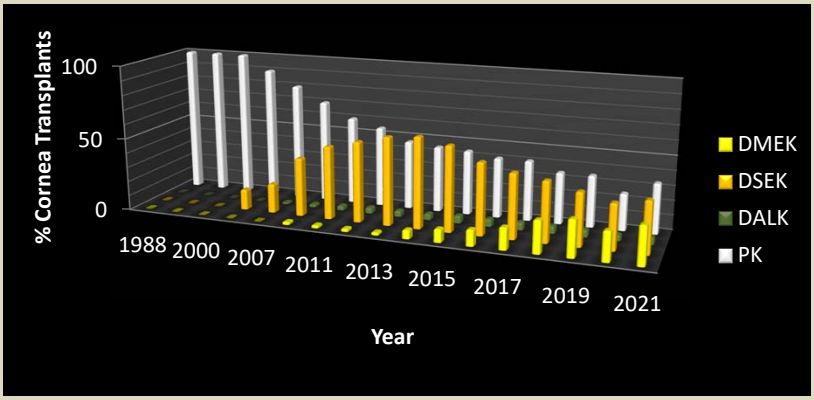


A healthy eye is more spherical in shape, allowing an image to come into focus clearly.

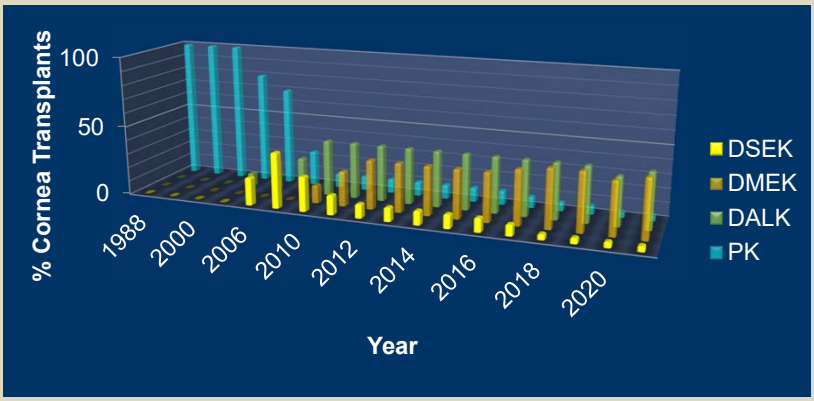
Cornea Transplantation: Variations:



Cornea Transplants: USA 1988-2022

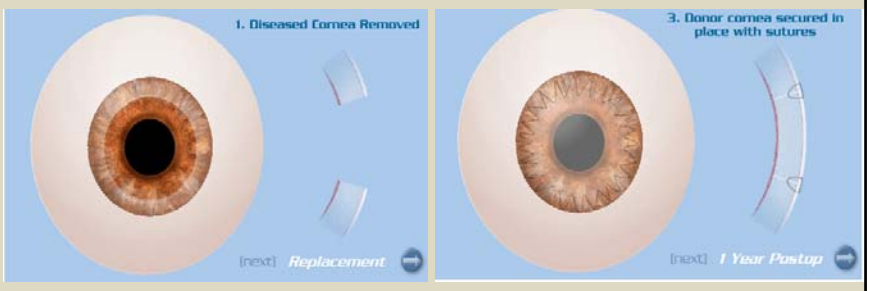


Cornea Transplants: Erdey-Searcy Eye Group 1988-2022

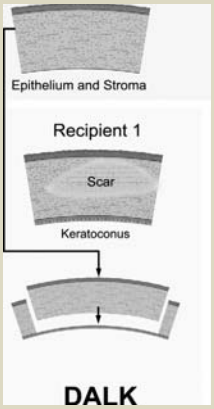


Penetrating Keratoplasty (PK)

What's wrong with it?



Deep Anterior Lamellar Keratoplasty (DALK) is BETTER, WHY?:

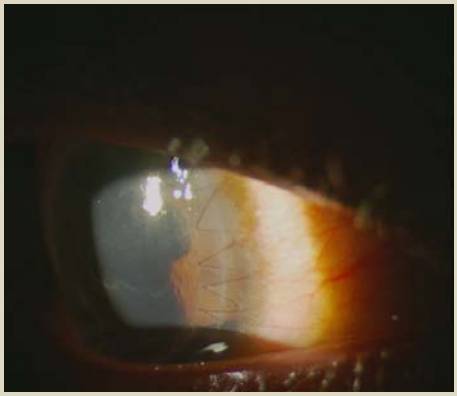


PK: Hazards…

- Unintended lensectomy
- Expulsive Choroidal Hemorrhage 0.56-1% UK

PK: Hazards…long-term

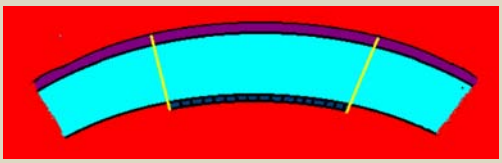
- Rejection and Failure
- Reduced survival of regrafts
- Glaucoma 19-30%
- Cataract
- Endophthalmitis
- Late Ectasia



Case report (ASCRS listserv)
PK's – Scourges
Cornea Graft Rejection

17 yo severe keratoconus, atopic dermatitis

- PK x 3
- Graft rejection/failure each time
- Regraft?
- Immune suppression: cytoxan?
- Keratoprothesis?



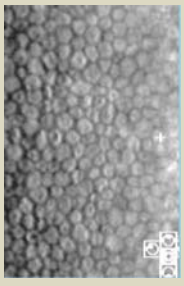
... there is no reasons for replacing an healthy endothelium... EVER!!!

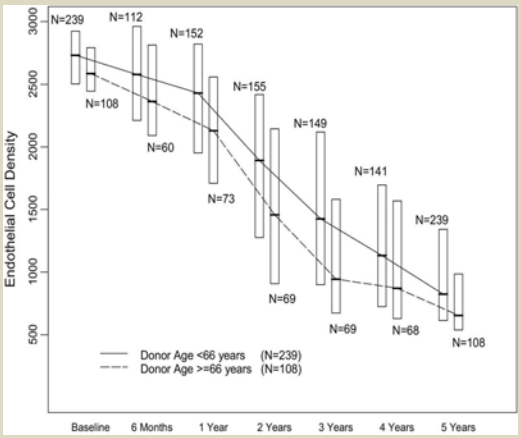
V. Sarnicola, ESCRS, 2009

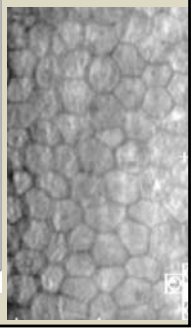
Cornea Donor Study

Cornea Donor Study Investigator Group

Ophthalmology 2008







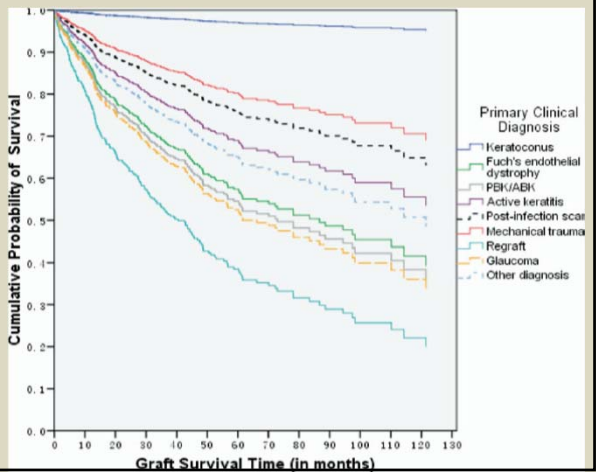
Cornea Donor Survival – PK

Penetrating Keratoplasty in Asian Eyes
The Singapore Corneal Transplant Study
Donald Tan et al Ophthalmology 2008

- 901 PK's up to 12 yrs
- Keratoconus 94.7%
- PBK/ABK 33.5%
- Fuchs' 20%

- Regraft 18.5% (5yr)
- Endothelial rejection

Late endothelial decomp
= 50.5% of failures

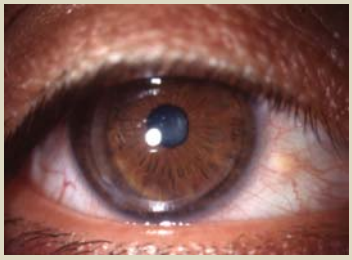


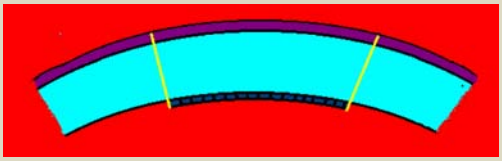
Ocular Surface Disease (OSD)
PK will FAIL. Must do DALK!

- Steven's Johnson Syndrome (SJS)
- Chemical or thermal injury
- Ectodermal Dysplasia
- Corneal stromal scarring or thinning from OSD

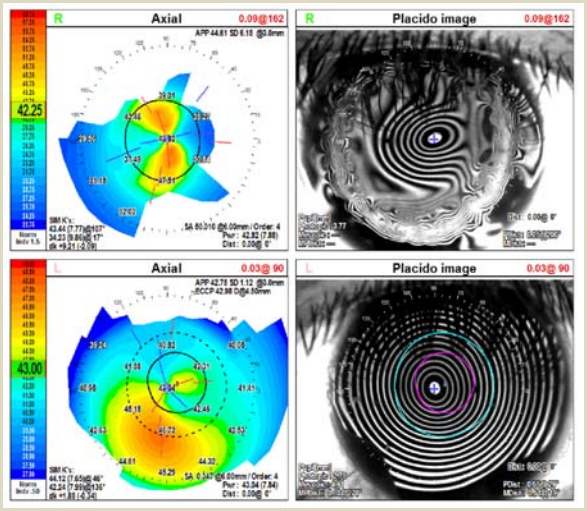
PK's – Scourges
Long visual recovery time

- 1 to 2 years before suture removal – final refractive result
- Risk of Traumatic Wound Rupture

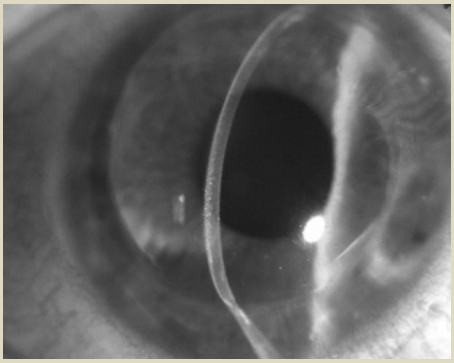




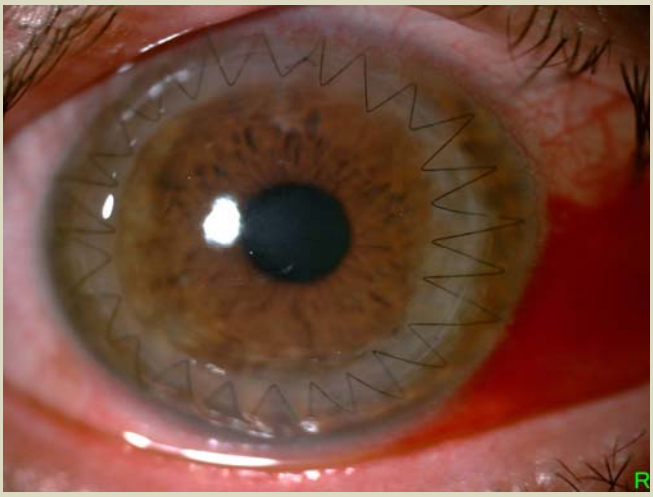
OD: 26 yo PK 8.25mm 7 mos ago
OD -2.0+6.0x116 20/70
OS: -3.75+2.0x26 20/20



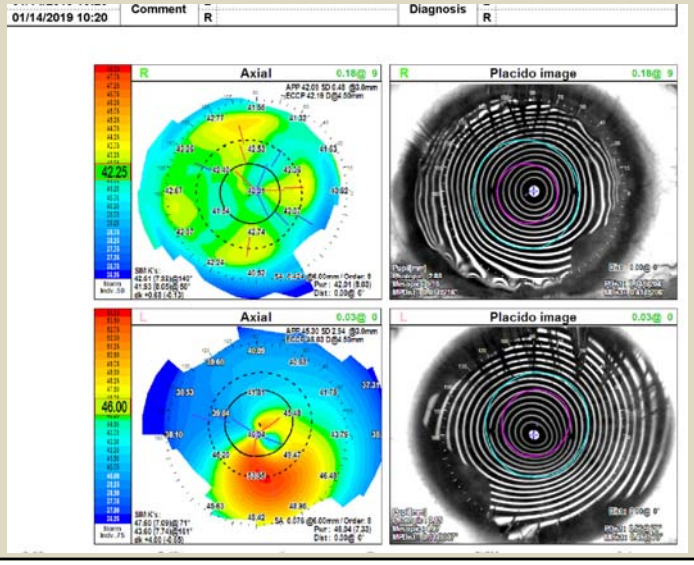
41 yo 2000 PK Keratoconus OD
2017 severe ectasia



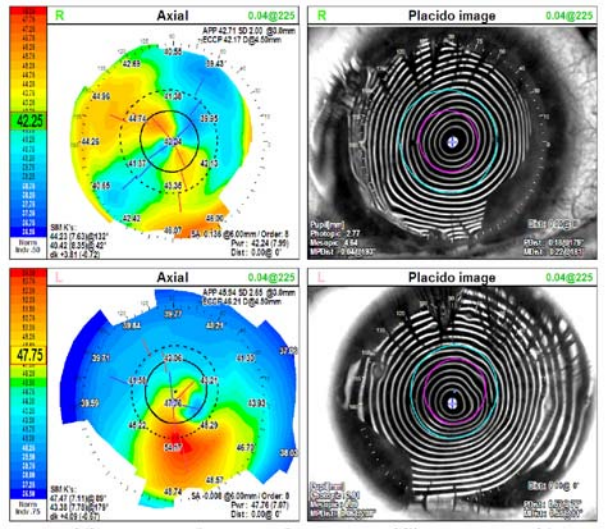
Repeat PK (9.0mm) Jan 2017
UCDVA 20/25 plano



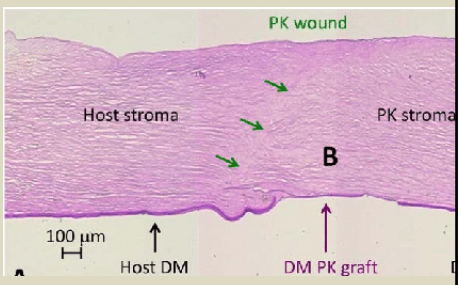
OD: 2yrs after REPEAT PK (9.0mm)
UCDVA 20/25 plano



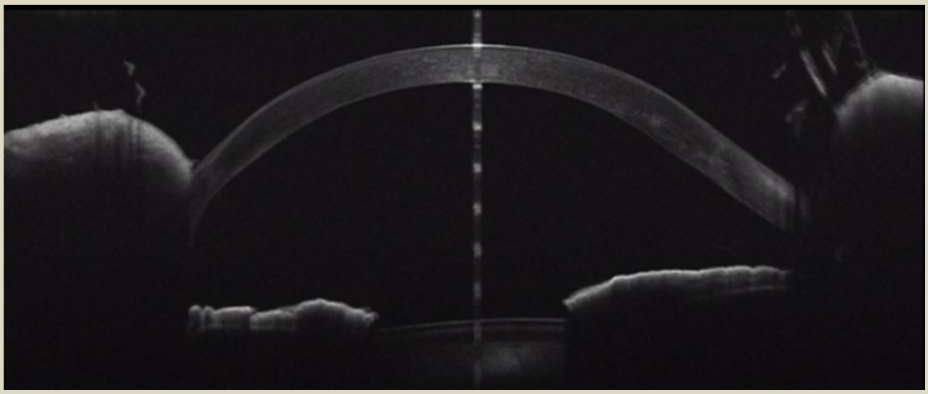
3 yrs later: Running Suture breaks – removed
UCVA drops to 20/100
now lives in Detroit



PKP



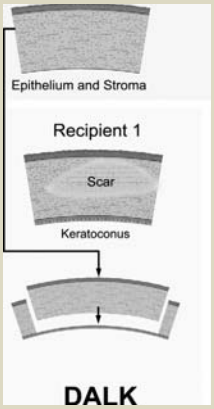
DALK: Superior Wound Coaptation and surface regularity



Malbran: DALK 9.5-11mm dia: 56 yrs follow up

- Not a single case of late ectasia
- large dia lamellar grafts are STABLE
- Under 8.5mm DALK: late ectasia reported

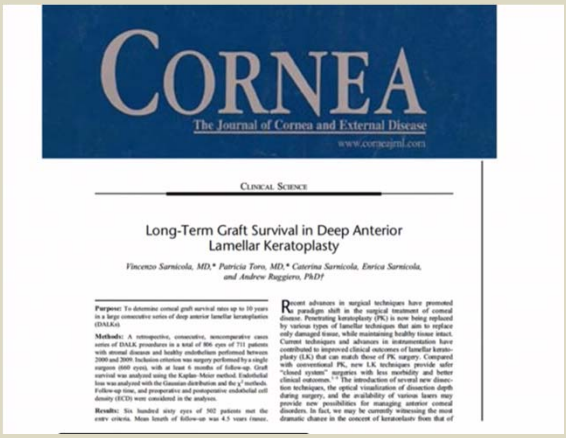
Deep Anterior Lamellar Keratoplasty (DALK) Challenge:



Deep Anterior Lamellar Keratoplasty (DALK) – Advantages over PK

- **NO ENDOTHELIAL Cell Ct decay/rejection!!**
- Closed surgery – safer
- Reduce steroid induced glaucoma
- Reduce secondary cataract
- Faster healing
- superior wound coaptation
- Superior optics (less HOA) – staged refractive surgery (suture-out astigmatism more regular)
- No long term ectasia
- Larger pool of donor tissue

Long Term Survival of DALK LAST A LIFETIME!


CORNEA
The Journal of Cornea and External Disease
www.corneajrnl.com

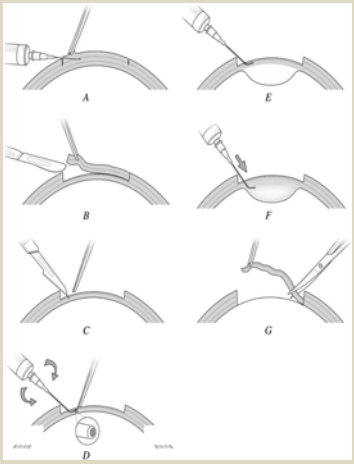
CLINICAL SCIENCE

Long-Term Graft Survival in Deep Anterior Lamellar Keratoplasty

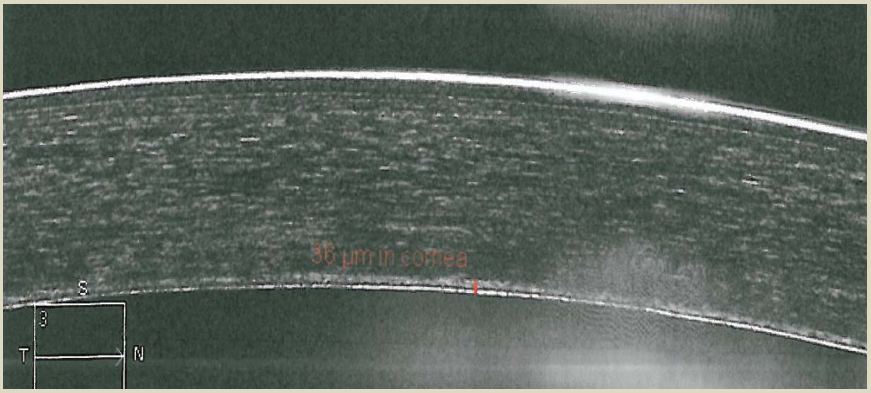
Vincenzo Sarnicola, MD, Patricia Toro, MD,* Caterina Sarnicola, Enrica Sarnicola, and Andrew Ruggiero, PhD†*

Cornea. 2012;31(6):621-626

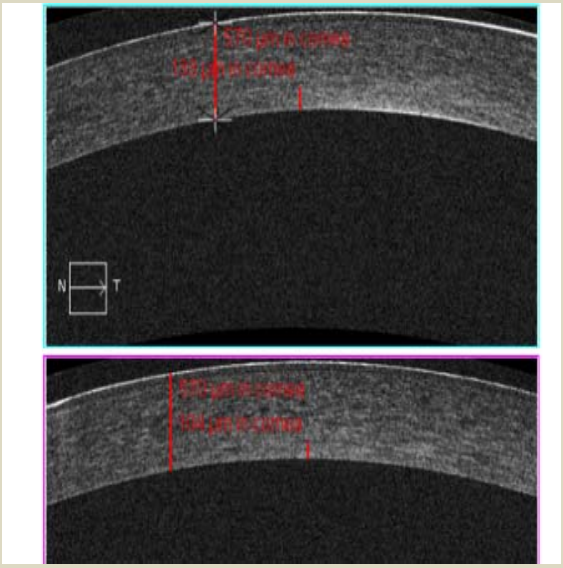
Deep Anterior Lamellar Keratoplasty (DALK) Big Bubble



DALK: pre-descematic (30u) optically best



Case 2: “Small-dia” (7.75mm) femto-assist (performed elsewhere) DALK OD pre-descemets dissection (residual stromal bed variable 100-133u)



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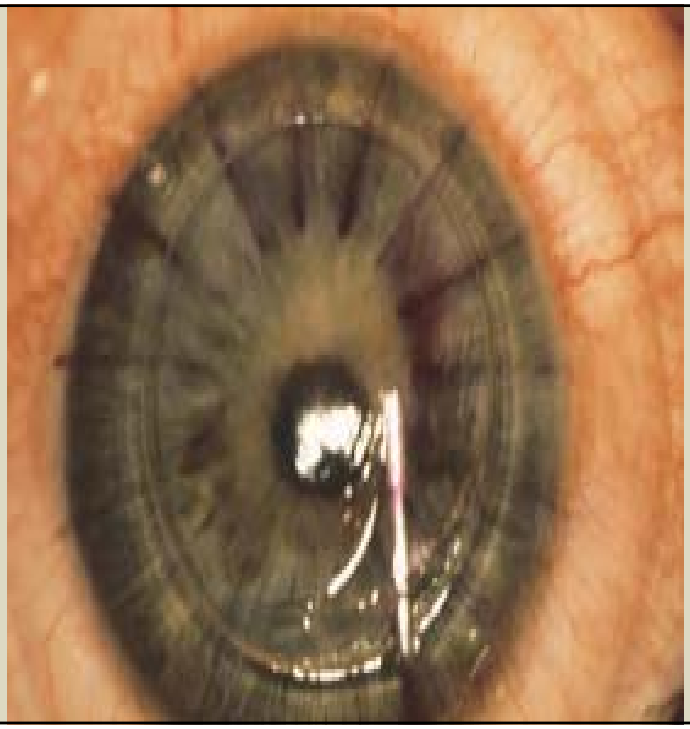
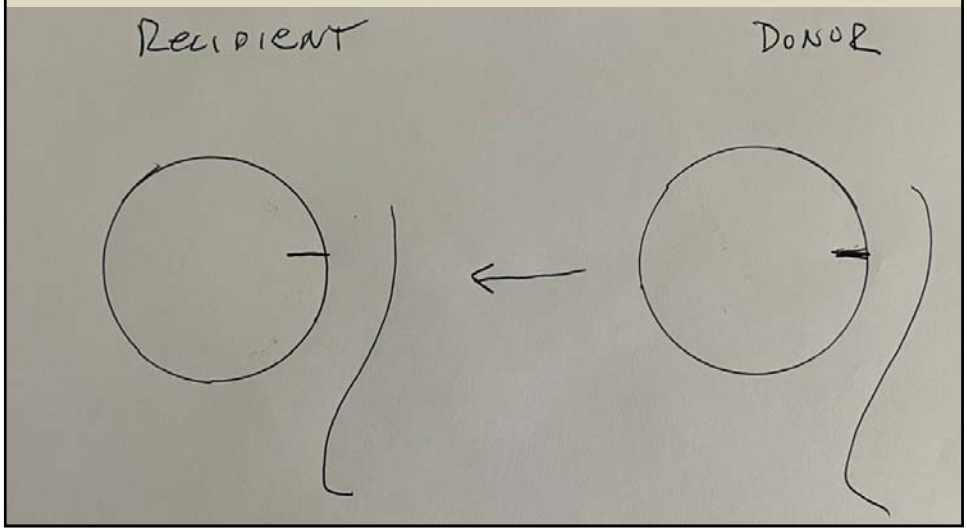
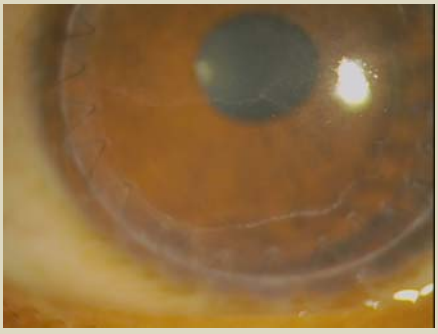


2021: GOAL improve cylinder: began Donor Laterality matching/registration in recipient bed

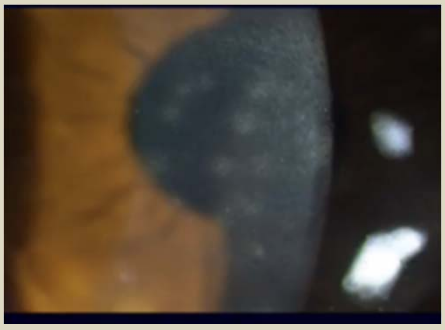


DALK – long term complications: Do lamellar grafts reject?

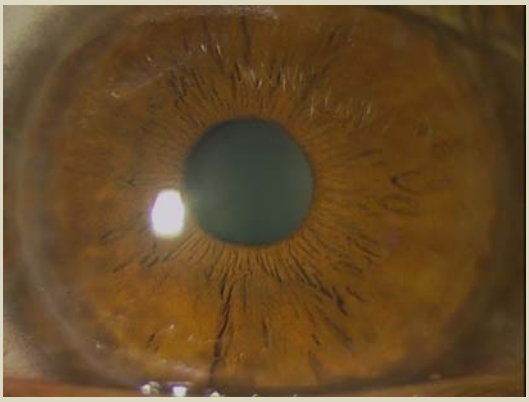
epithelial



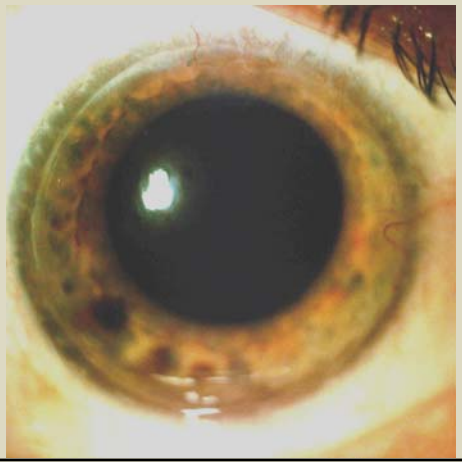
stromal

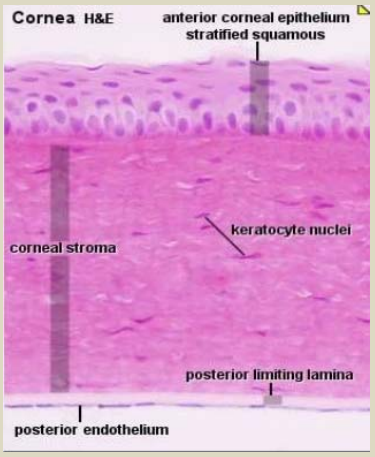


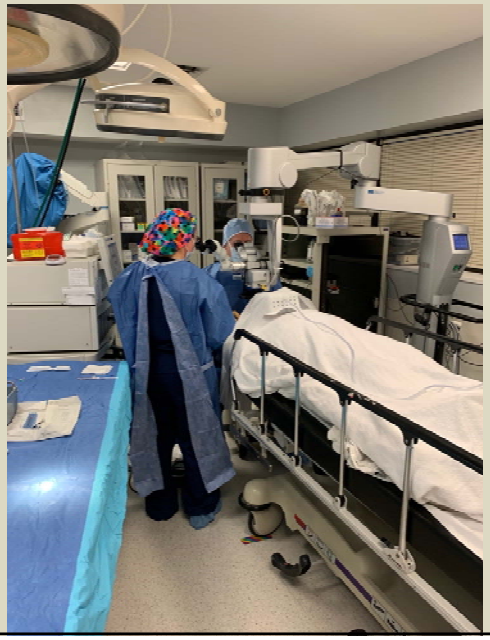
DALK: Rejection – epithelial or stromal after treatment with Pred Forte



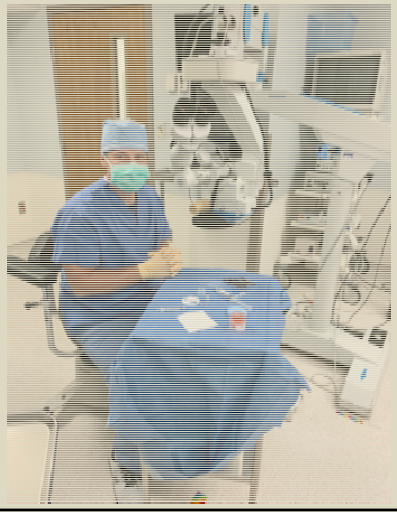
Long term: repopulate with host cellular elements





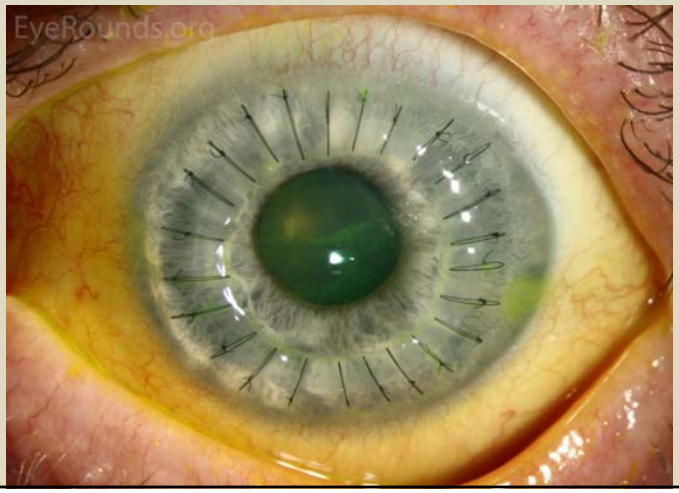


We prefer use of a second O.R. to prepare the donor tissue while DALK performed in other O.R.



DALK: Is it Adjustable?

Small Dia DALK - interrupted suture
NOT adjustable



Early Visual Rehabilitation Following Keratoplasty Utilizing Single Continuous Suture Technique

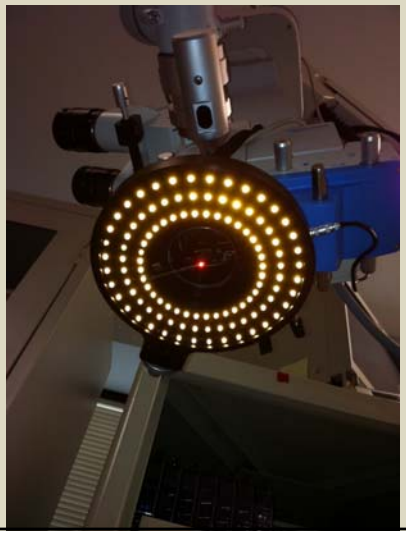
- My preferred technique
- Before reliable Topographers or intraoperative keratometers

Ophthalmic Surgery 22 (4). April, 1991. Temnycky GO, Lindahl KJ, Aquavella JV, Erdey RA

Intraoperative Keratometers - Mastel

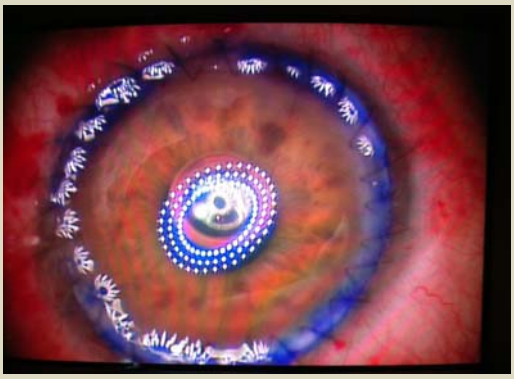
original

New



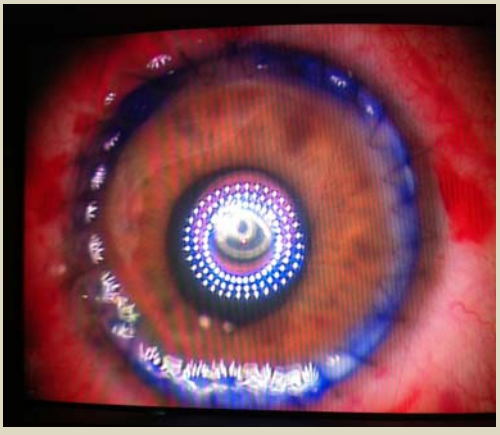
Intraoperative Keratometer

DALK/PK – before suture adjustment



Intraoperative Keratometer

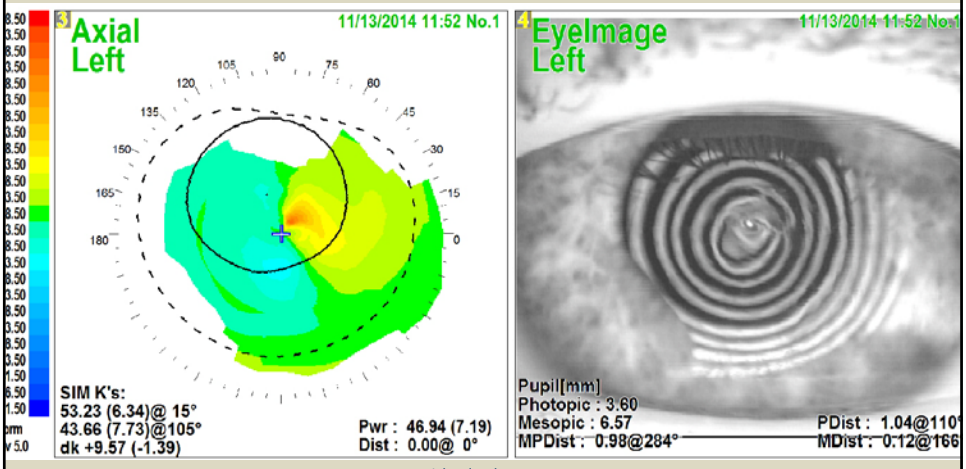
DALK/PK – after suture adjustment:
improves early optical rehabilitation



How quickly can I start to see?

- PK – years (maybe)
- DALK – few weeks (sometimes less!)

31 yo Male Cleveland
OS: severe keratoconus/central cornea scar VA 20/300
OD: PKP 2004



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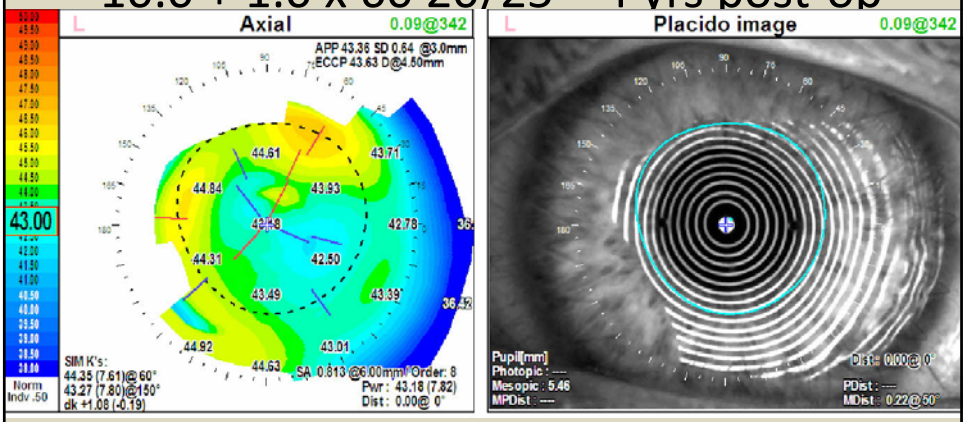
Large Diameter DALK (10mm dia)
-10.0 + 1.0 x 60 20/25 4 yrs post-op



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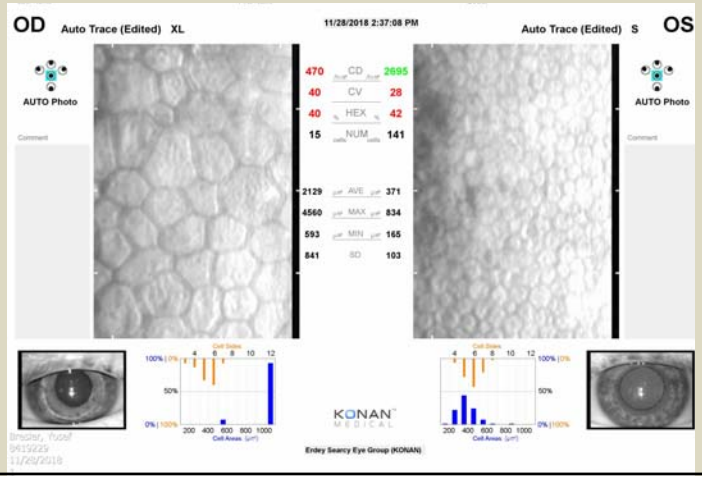
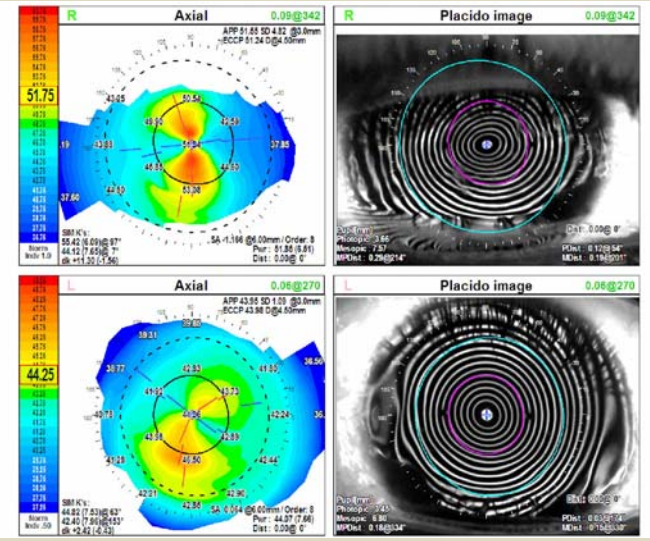
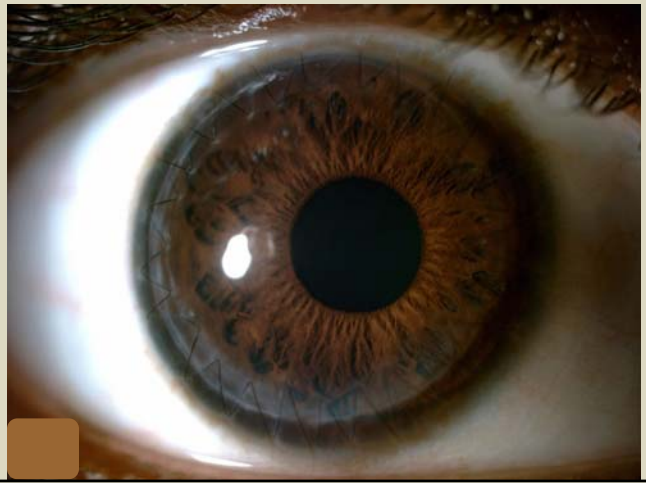
Now pt is 35yo
15yrs OD: PKP 4yrs OS: DALK



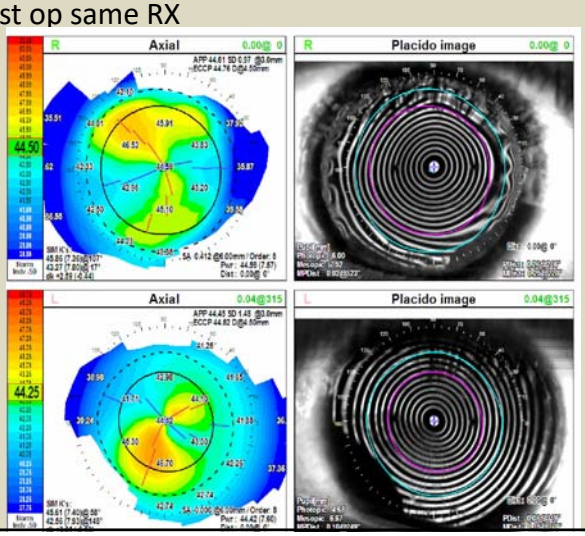
32yo female severe Keratoconus OD>OS RGP intolerant OD,
Disabled and insurance challenges
OD: -13.50+8.0x100 20/200
OS: -2.0+2.5x57 20/30



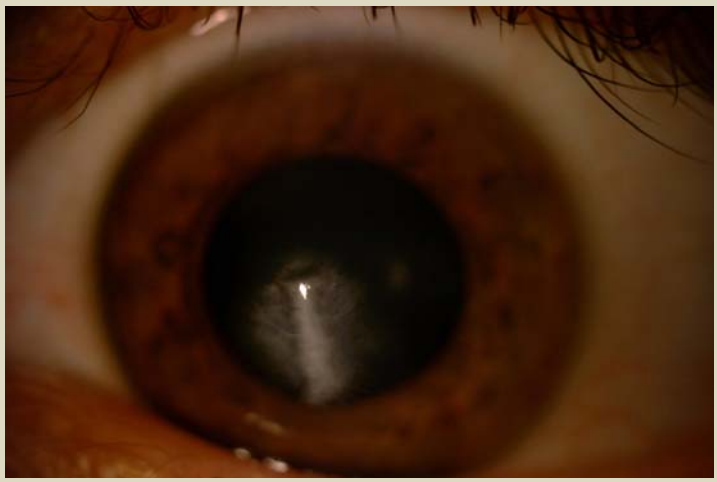
Oct 2018: DALK 9.5mm

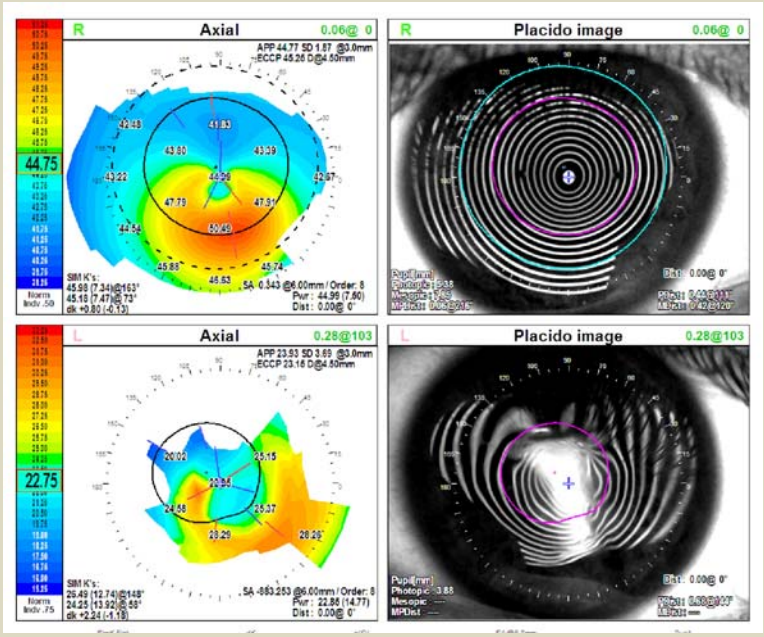


1 wk post op OD: -5.25+2.25x140 20/40
3 wks post-op OD: -4.75+1.75x140 20/25 dispensed RX
OS: -2.0+2.5x57 20/30
I year post op same RX

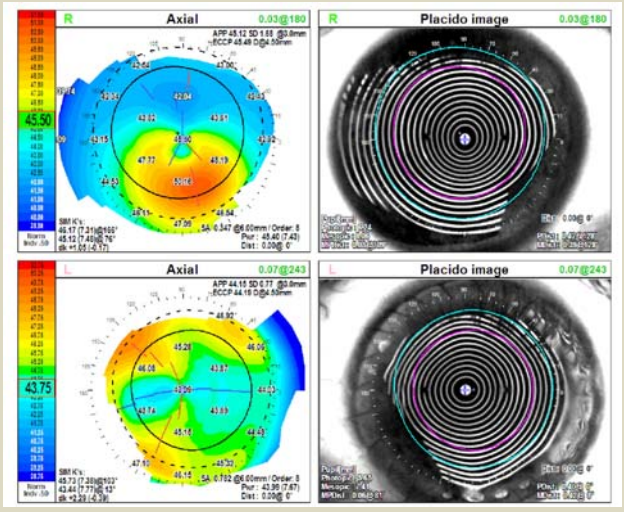


27 yo severe keratoconus OS

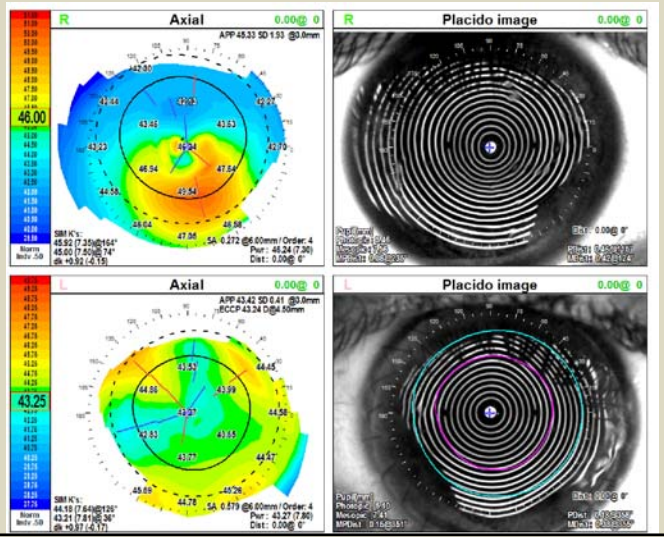




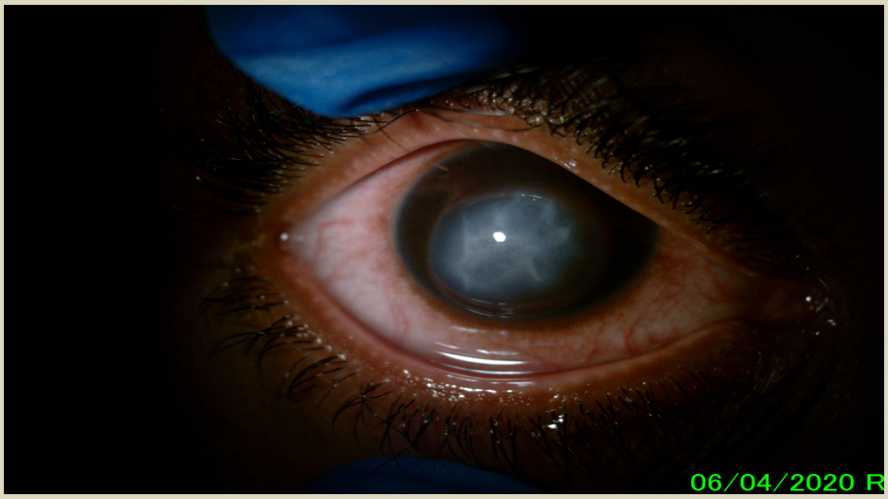
Jan 22, 2019 DALK 10.0mm OS
2 mos later: UCVA 20/40



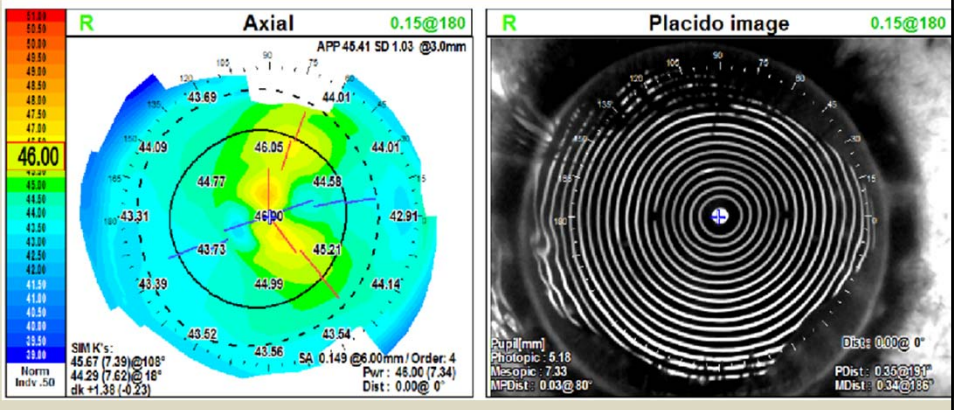
Jan 22, 2019 DALK 10.0mm OS
1yr later: UCVA 20/25
-0.75 20/20



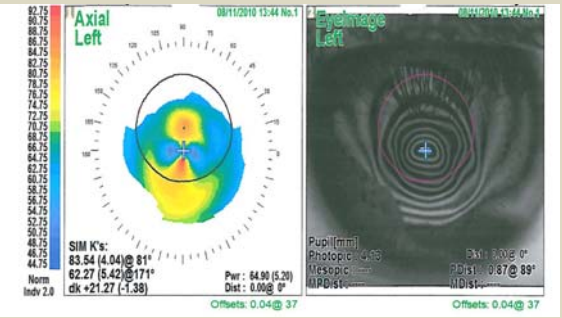
Hydrops

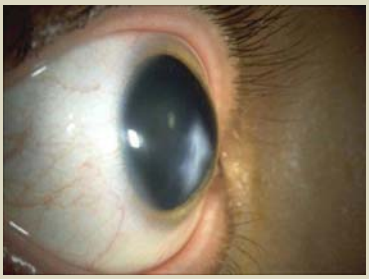


8 mos after DALK
-10.0+1.5x120 20/20 !

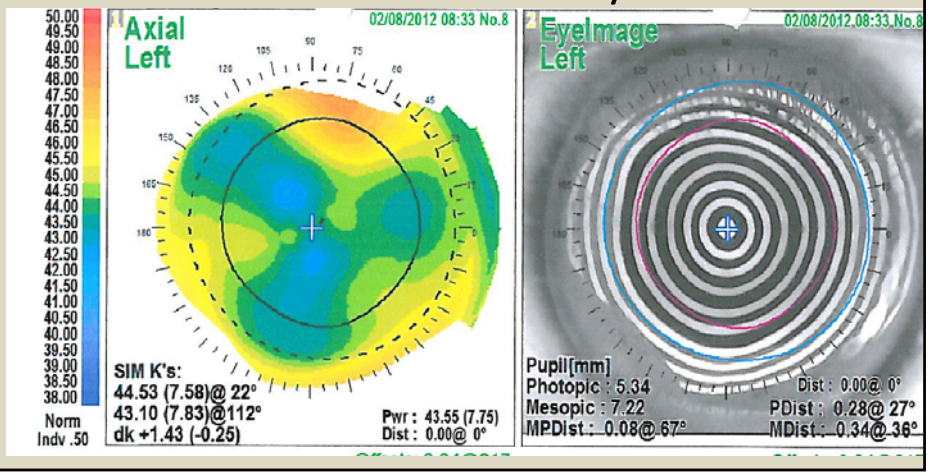


Severe Keratoconus with scar
hx of cornea hydrops – age 19

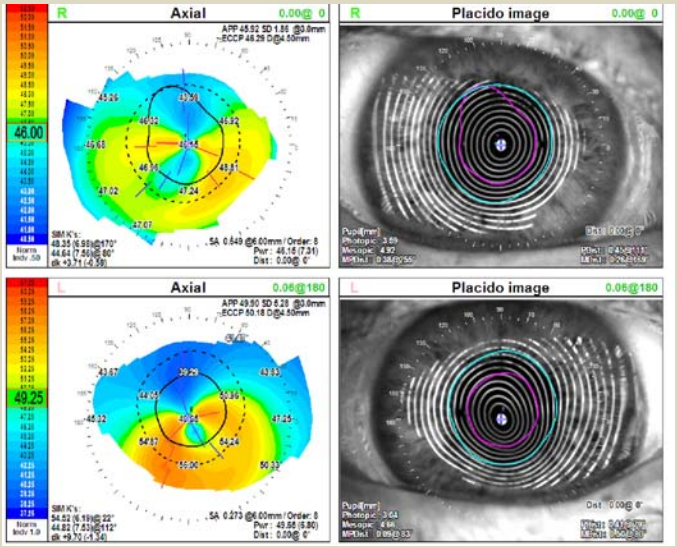




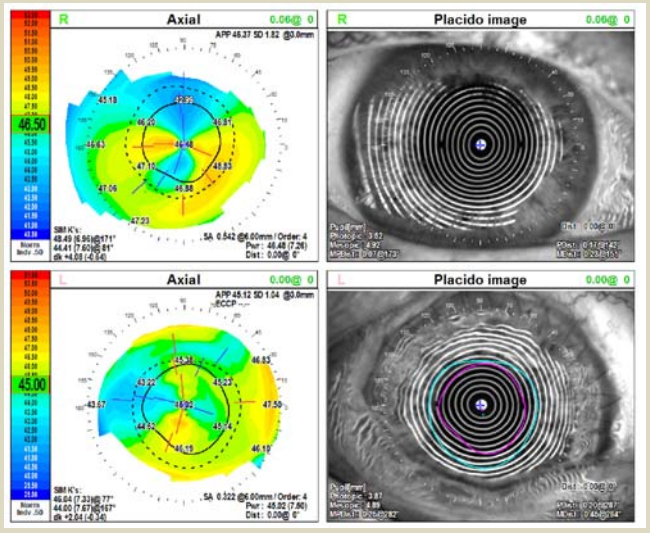
Severe Keratoconus with scar
20 yo 15 mos aft DALK suture out
- 5.0 + 0.5 x 20 20/20
Visian ICL UCVA 20/20



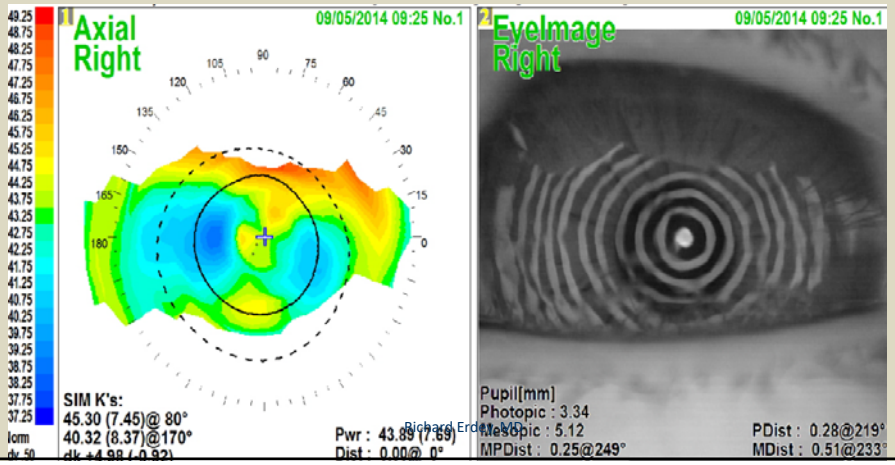
68 yo Pellucid Marginal Degeneration OS>OD



69 yo Pellucid Marginal Degeneration
OD: Cataract Ext high toric IOL UCVA 20/25
OS: 1 year DALK 9.5mm dia. -0.75+0.5x105 20/30



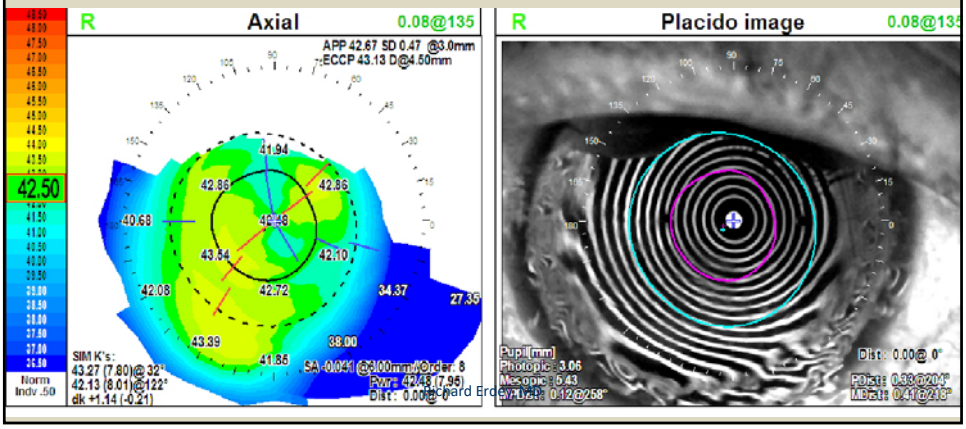
37 yo male Severe Reis Bucklers Cornea Dystrophy VA 20/400 pre-op



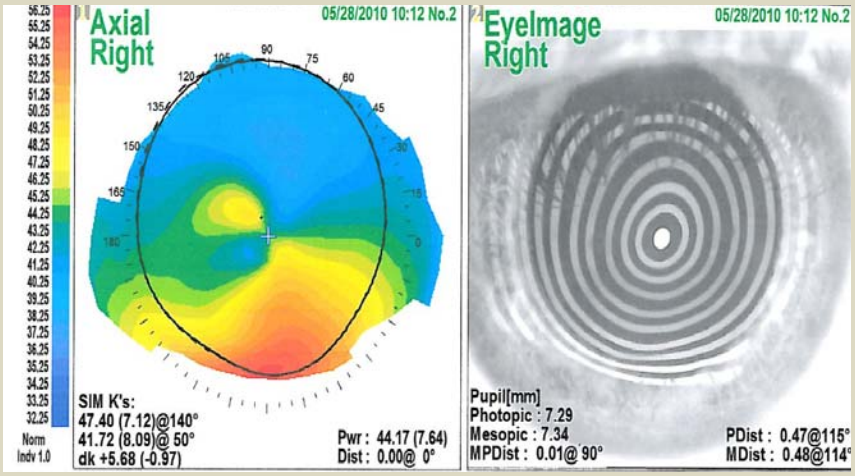
37 yo male Severe Reis Bucklers Cornea Dystrophy 1 wk after DALK 9.5mm dia.

VA 20/20 UNCORRECTED!

VERY EARLY EXCELLENT Visual Rehabilitation!



LASIK Ectasia: 48yo male, CL intol
-7.0 + 7.0 x 20/50



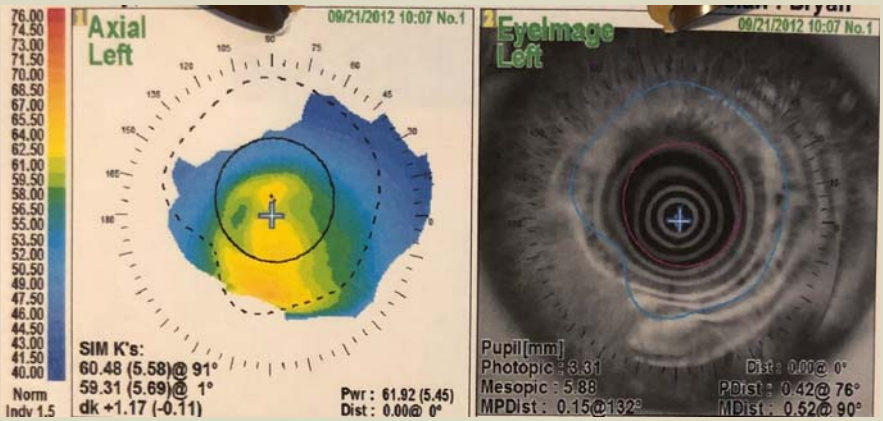
DALK: 8 mos post-op (2 mos after
suture removed)
+1.25 + 1.5 x 175 x 20/20-

Keratoconus/Dalk/Long term stability?

Case 5

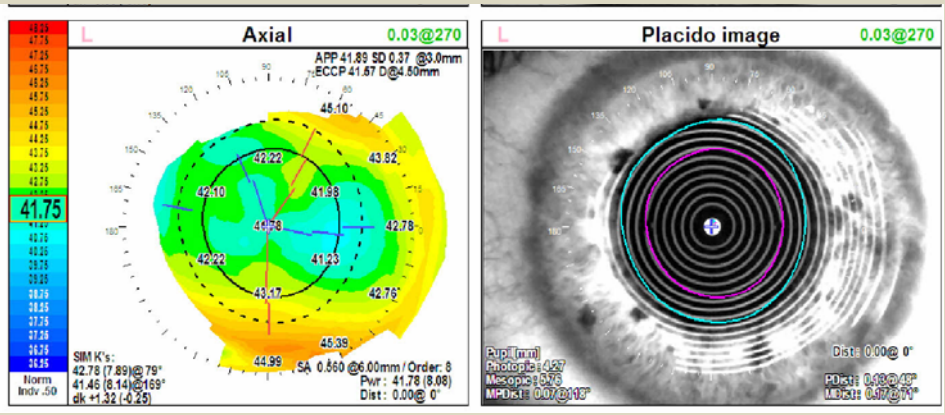
Left Eye

12/18/12 23yo male Keratoconus -19+6.25x93 20/300 DALK 9.5mm pre-descemets dissection



Case 5 Left Eye

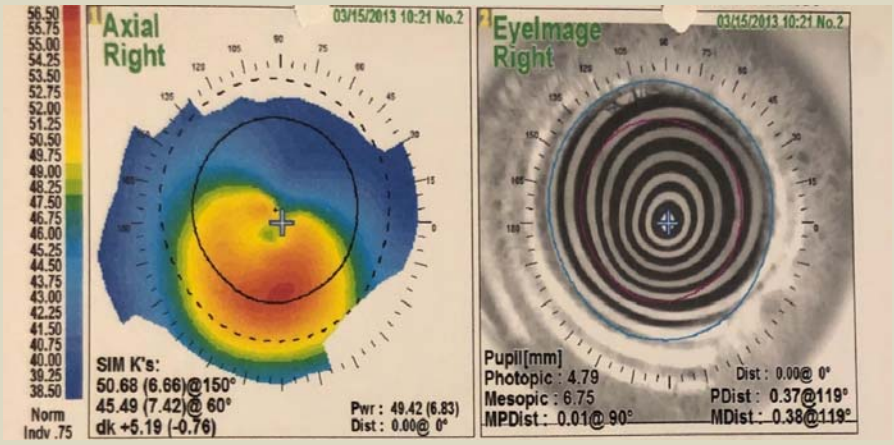
10/2018 (6yrs aft DALK, 1.5yrs aft LASIK)
UCVA 20/20-1 -1+0.5x135 20/20



What about his right eye?

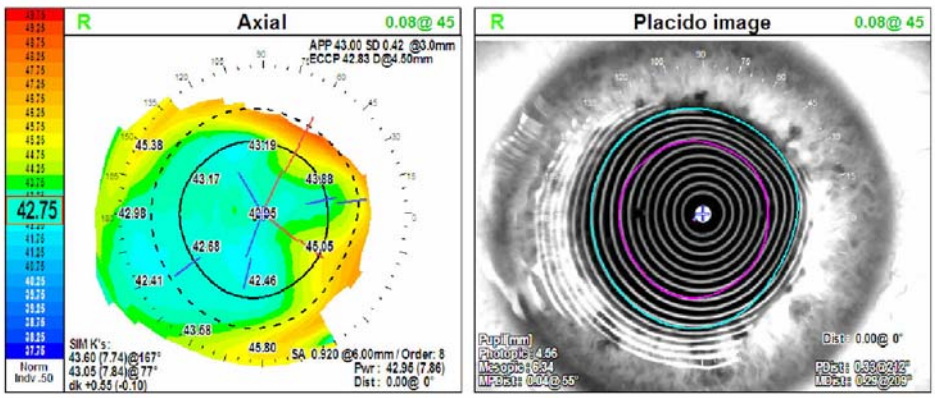
Case 5 **Right Eye**

3/15/2013 24 yo male Keratoconus -6.0+3.75x133 20/40



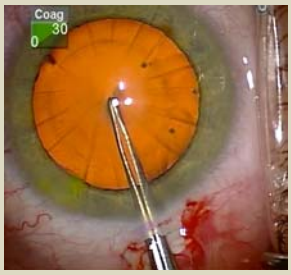
Case 5 **Right Eye**

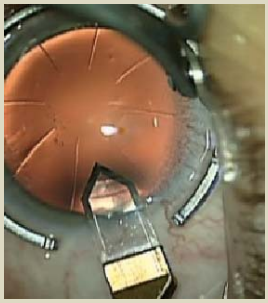
10/2018 29yo (5yrs aft DALK/1yr aft LASIK,) OD: UCVA 20/25 -0.75 20/20



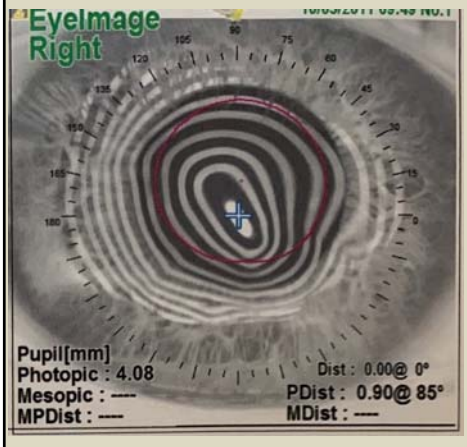
POST RK CORNEA – and cataracts?

- "The gift that keeps on giving"
- • Hyperopic progression
- • AM to PM fluctuation
- • IOL power calculation
- • Hyperopic surprises
- • Difficult to obtain flattest "K"
- • Add IOL power – up to 2.5 D
- • Caution with Aberrometry
- • Caution with Toric IOLs
- • Avoid trans-section of RK/AK cuts
- • Transient post-op hyperopic shift





Case 2: Bilateral severe RK ectasia 64yo
OD 20/150 OS 20/200



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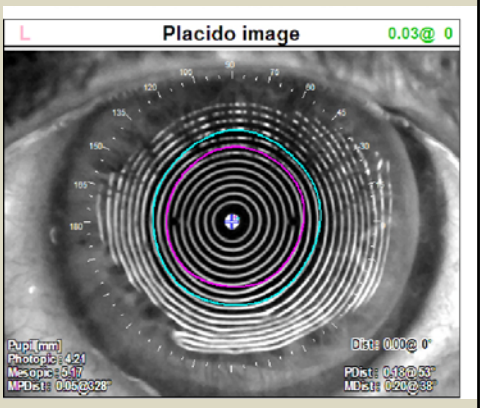
Left eye: 8 yrs after DALK, Happy endings!!
8/2019 Cataract Ext with low power toric IOL

- UCVA 20/30
- -0.75+ 0.75 x 50 20/20



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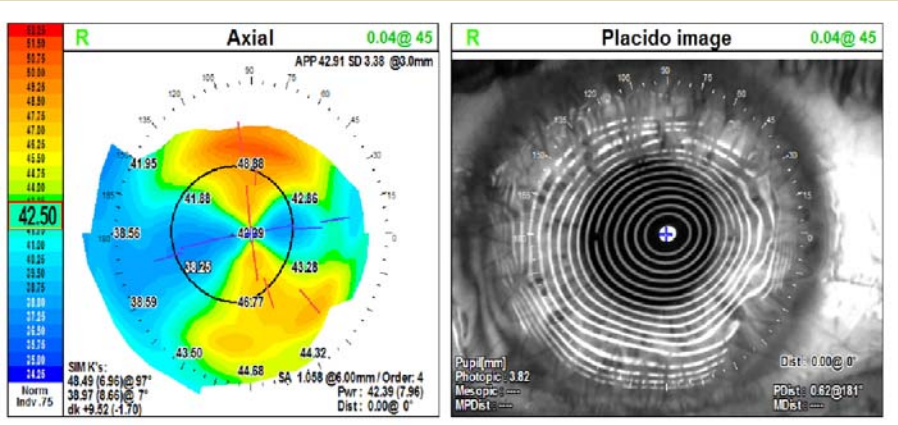
Right Eye:
7 years after DALK Happy endings!!
10/2019 Cataract Ext with low power toric IOL OS

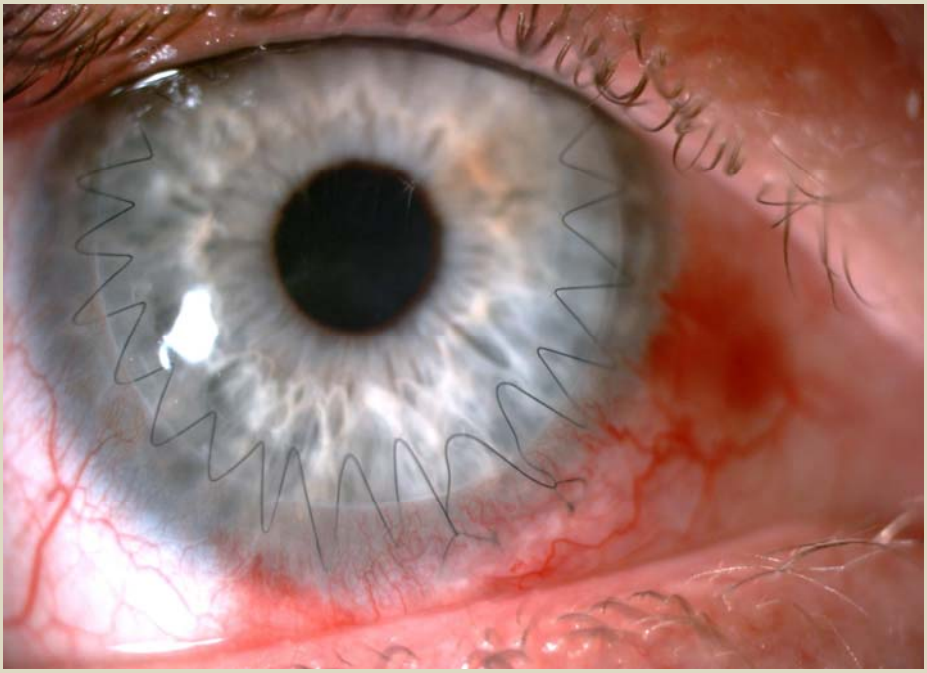
- UCVA 20/30
- -0.50+ 0.75 x 20 20/30

Richard Erdey MD

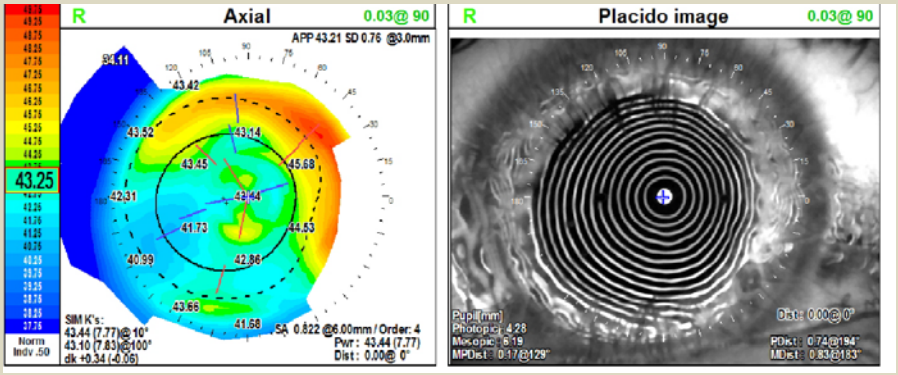
Is DALK Adjustable in early post-op period?

Case: 18yo Keratoconus 5 wks DALK

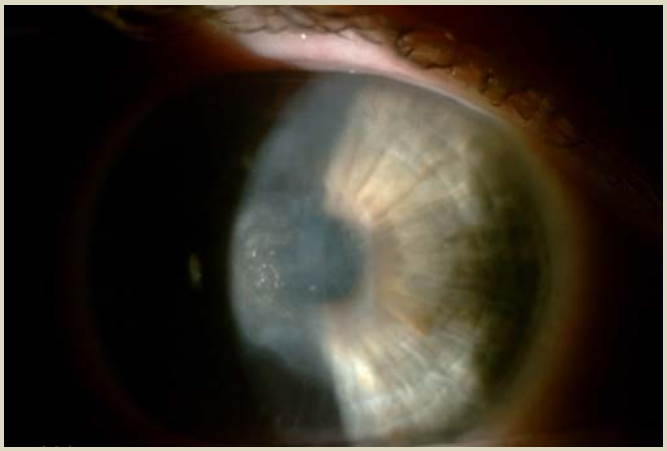




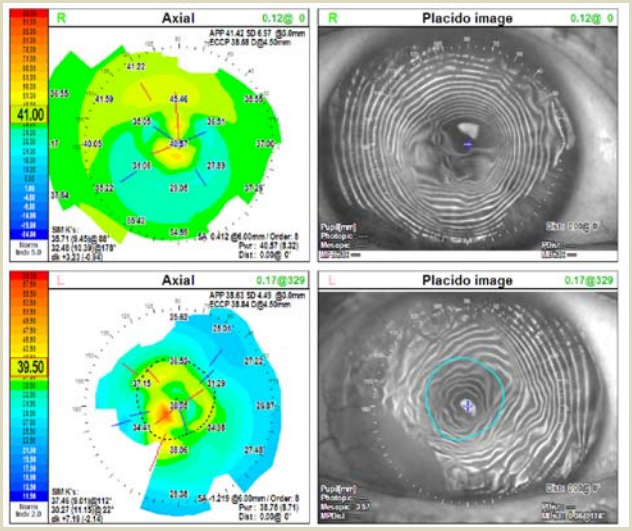
2 wks after running suture adjustment:
UCVA 20/40 +0.5+0.75x78 20/30



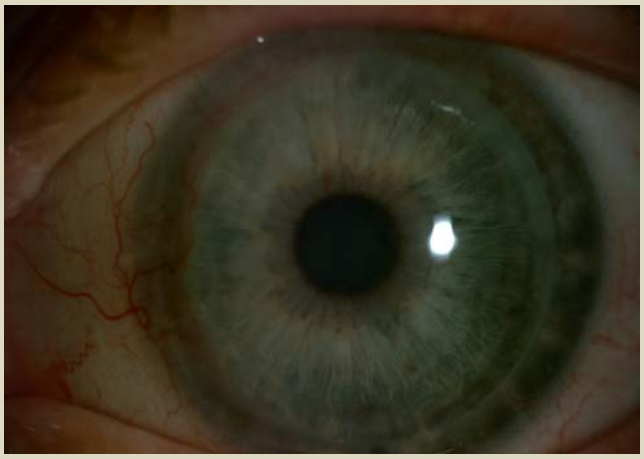
57 yo FM Bilateral Central Thinning and Cornea scars /HSV 1982 BSCVA 20/400 EACH EYE!



57 yo FM Bilateral Central Disabled since age 21!

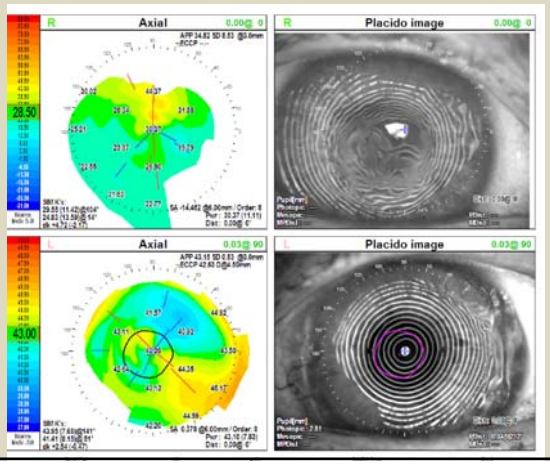


57 yo FM Bilateral Central Thinning Cornea scars /HSV
8/2018 OS DALK 9.0mm
3/2019 OS UCVA 20/50

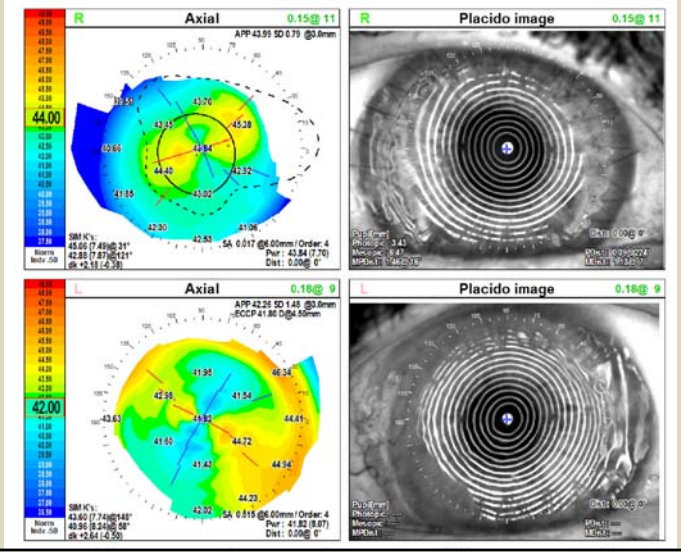


57 yo FM Bilateral Central Thinning and Cornea scars /HSV
8/2018 DALK OS
3/2019 OS UCVA 20/50 mild residual haze DM preferable to sacrificing it as would with PK!

57 yo FM Bilateral Central
8/2018 DALK 9.0mm
3/2019 OS suture out UCVA 20/50

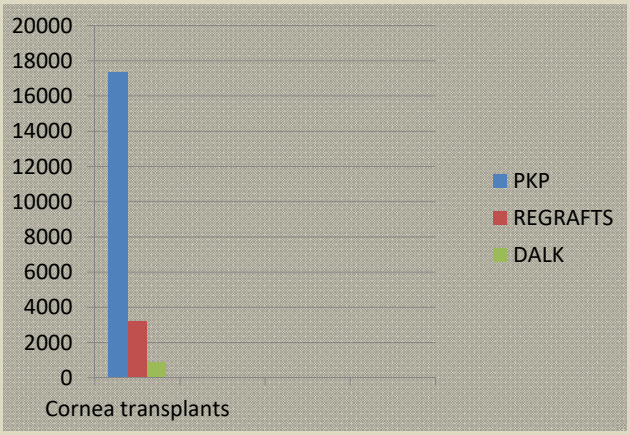


57 yo FM Bilateral Central scars (since age 21)
8/2018 OS DALK 9.0mm 4/2019 DALK OD 9.5mm
8/2019 OD -1.0+1.75x30 20/30 OS plano+1.75x150 20/40



DALK vs PK - 2022 USA

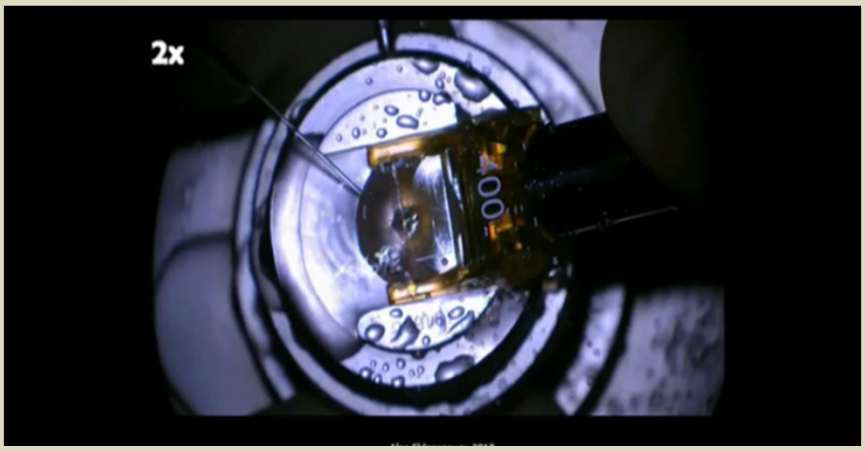
Are we conserving recipient endothelial cells during surgery and what is long term graft survival? ANSWER = NO!!!



DALK: Training issues

- "We need more existing or new cornea surgeons willing to learn and master DALK with a goal of NO conversions to PK…"
- Cornea Fellowship directors need to emphasize DALK training in their programs

DALK: Automate stromal dissection? Microkeratome?



DALK: Femtosecond laser deep dissection?

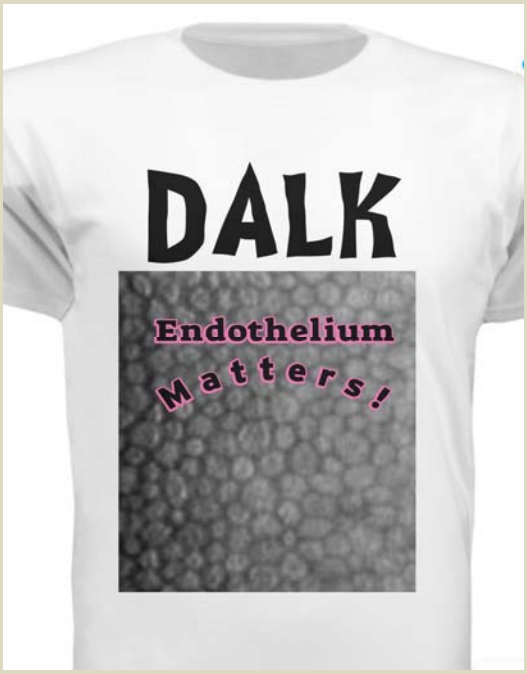
Summary DALK large diameter: "THE GOLD STANDARD"

- superior optics, visual clarity, adjustability and long term stability vs PK
- DALK grafts last a lifetime (exception cornea dystrophies –reversible - require peel/replace lamellar graft)
- PK gift that keeps giving!
- Avoid crosslinking warped corneas if DALK surgeon available

When referring pts with Corneal:

- Warpage
- Scarring

- consider surgeon capabilities…
- DALK experience? Conversion rate?


DALK
Endothelium
Matters!