

FLAUM EYE INSTITUTE
INSTITUTE OF OPTICS

Wavefront-guided Corneal Crosslinking

Geunyoung Yoon, PhD
Professor

Advanced Physiological Optics Laboratory
Flaum Eye Institute, The Institute of Optics,
Center for Visual Science, Biomedical Engineering
University of Rochester

UNIVERSITY OF ROCHESTER
MEDICAL CENTER

Keratoconus

- Cone-shaped cornea
- A non-inflammatory eye condition
- Progressive local thinning
- Irregular astigmatism
- Significant visual impairment.

Pantanelli et al., Ophthalmology (2007)
Yoon et al., J Biomed Opt. (2006)

Mechanical: Progressive weakening
Scarcelli et al., JAMA Ophthalmol. (2015)

Optical: Large aberrations

Current Approaches

Optical: Ophthalmic lenses (Corneal, Hybrid, Scleral, Intacs....)



Mechanical: Corneal Collagen Crosslinking with Riboflavin (CXL)

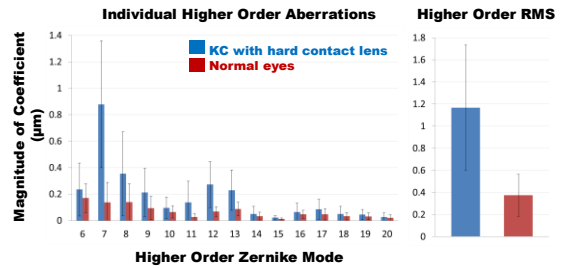


Corneal Transplant Surgery: Scarring, extreme thinning or contact lens intolerance



Current most popular solutions i.e. corneal (RGP) and scleral lenses do not provide sufficiently good optical quality of the eye compared to normal eyes.

Sabesan et al., Optom Vis Sci (2013)

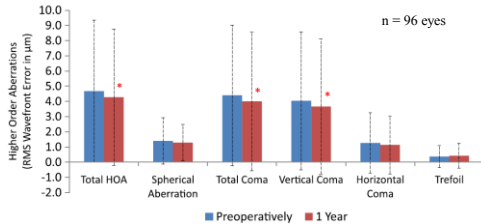


Optical Limitation of Conventional CXL

Higher-order aberrations after corneal collagen crosslinking for keratoconus and corneal ectasia

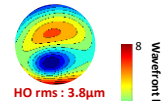
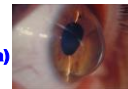
Sivens A. Greenstein, MD, Kristin L. Fry, OD, MS, Matthew J. Herlihy, Peter S. Hersh, MD

J Cataract Refract Surg 2012; 38:292-302

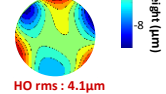


Higher order aberrations after corneal transplant.

Keratoconus (cone-shaped cornea)



Penetrating Keratoplasty (transplant cornea)



The goal is

to develop a way to resolve both optical and mechanical problems in keratoconus

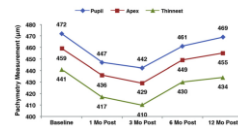
The hypothesis to be tested is that....

UVA intensity modulation can vary corneal response to crosslinking in terms of optical thickness without sacrificing the mechanical stiffening effect.

ARTICLE
Corneal thickness changes after corneal collagen crosslinking for keratoconus and corneal ectasia: One-year results

Steven A. Greenstein, BA, Vinne P. Shah, MD, Kriston L. Fry, OD, MS, Peter S. Hersh, MD

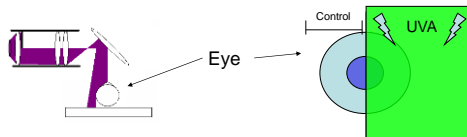
J Cataract Refract Surg 2011; 37:691-700



Author	n	Avg. ACCT (µm)	Post-op Exam	Method	
Barbosa et al.	2010	17	-54.5	3 months	UP
Rymond et al.	2009	15	-117.8	Immediate	UP
Raskup-Rlof et al.	2008	142	-2	12 months	UP
Raskup-Rlof et al.	2008	66	+21	24 months	UP
Romgajainen et al.	2007	10	-12	Immediate	UP
Mazzotta et al.	2006	10	+12	6 months	UP
Laprossa et al.	2005	10	+18.1	3 months	UP
Barbosa et al.	2010	17	+80.9	3 months	UP
Boors et al.	2009	8	+53.3	6 months	OCT
Boors et al.	2010	4	-5	12 months	OCT
Viniquerra et al.	2010	4	-10.6	6 months	Schein
Viniquerra et al.	2010	6	-5.09	12 months	Schein

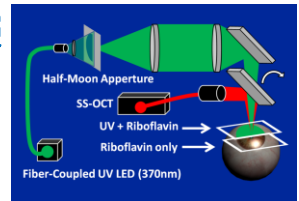
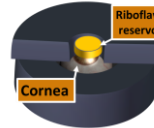
Experiment Protocol

- Standard procedure taken from Wollensak G, Spoerl E, Seiler T
 - Remove central 6.5-9mm of epithelium w/ blunt spatula
 - Riboflavin 0.1% + dextran T500 20% solution used
 - Pretreat with riboflavin solution
 - UVA source: 370nm, 3mW/cm
 - Irradiate for 30 minutes, adding drops every 5 min: 5.4J/cm2
- Occluding half the eye to create control**



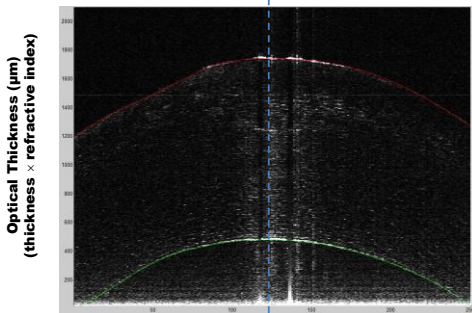
Crosslinking Procedure

A custom eye container with 1cm circular well allows continued soaking of riboflavin over debrided cornea



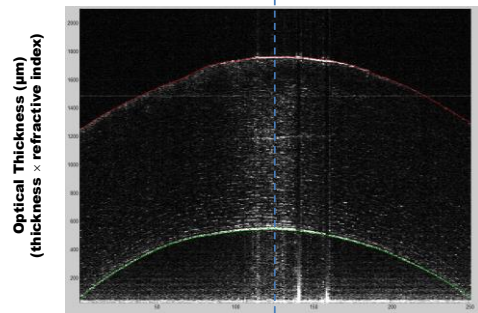
0 Min CXL

UVA No UVA

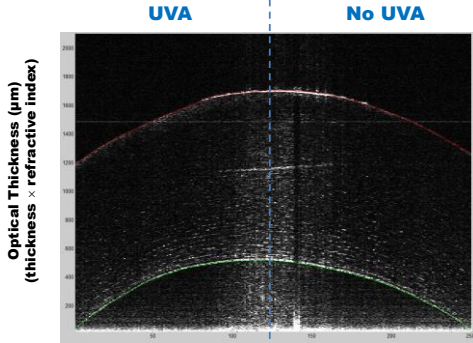


5 Min CXL

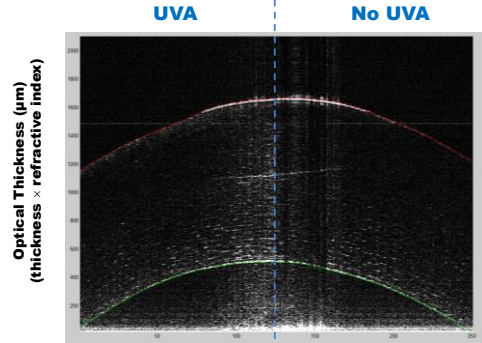
UVA No UVA



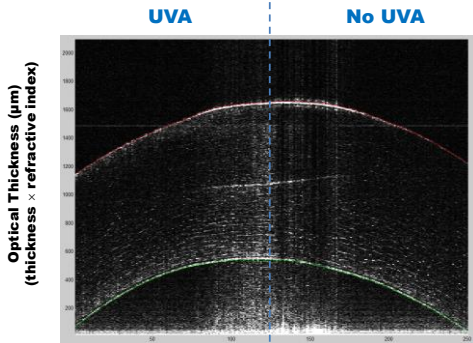
10 Min CXL



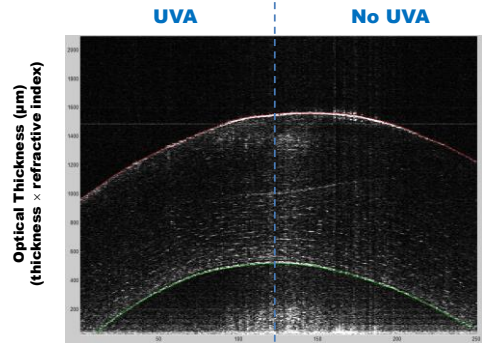
15 Min CXL



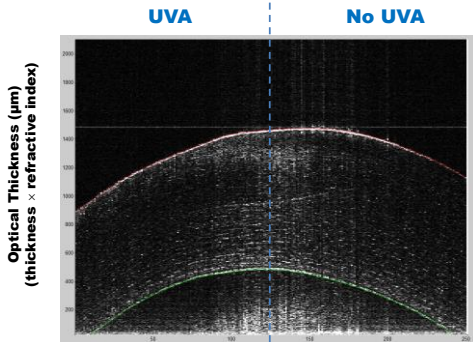
20 Min CXL



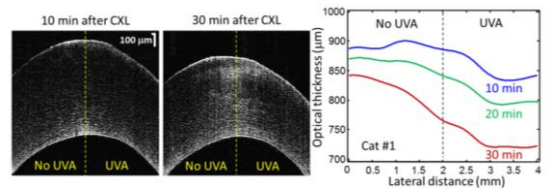
25 Min CXL



30 Min CXL



Corneal thinning is proportional to a duration of UVA illumination.



Discussion & Future Directions

- **UVA illumination onto cornea soaked with Riboflavin induces corneal thinning that has a proportional relationship with a duration of UVA exposure.**
- **Unanswered questions**
 - **Controllability of spatial variation and magnitude of the thinning?**
 - **Corneal wound response?**
 - **Uneven mechanical stress?**
 - **Longevity of the optical and mechanical changes**
 -
 -