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No Financial Disclosures

Collaborators

- Giuliano Scarcelli, PhD
- Johnny P. Su, PhD

- Fischell Department of Bioengineering, University of Maryland, College Park, MD, USA

LASIK Combined with Cross-Linking CONCEPT

- Provide cross-linking:
    - Sufficient to improve corneal strength
    - Insufficient to induce conceal flattening

    - “Just Right” amount needed

LASIK Combined with Cross-Linking GOALS

- Reduce ectasia risk in at risk eyes
- Reduce regression risk
    - Myopic surgery
    - Hyperopic surgery
- Conflicting results in literature

LASIK Combined with Cross-Linking

Topography-guided Hyperopic LASIK With and Without High Irradiance Collagen Cross-linking: Initial Comparative Clinical Findings in a Contralateral Eye Study of 34 Consecutive Patients

Anastasios John Kanellopoulos, MD; Jonathan Kahn, MD

[*J Refract Surg*. 2012;28(11 Suppl):S837-S840.]

Topography-guided Hyperopic LASIK With and Without High Irradiance Collagen Cross-linking: Initial Comparative Clinical Findings in a Contralateral Eye Study of 34 Consecutive Patients

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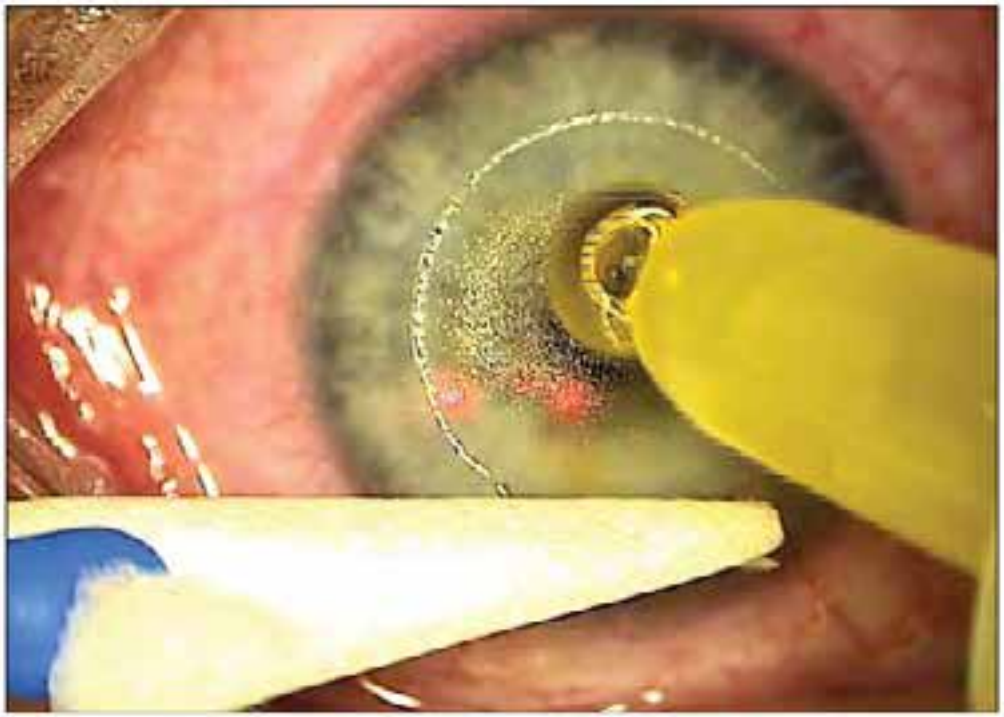

Figure 1. Riboflavin is instilled on the bare stromal bed. Care is taken to avoid contact with the folded LASIK flap.

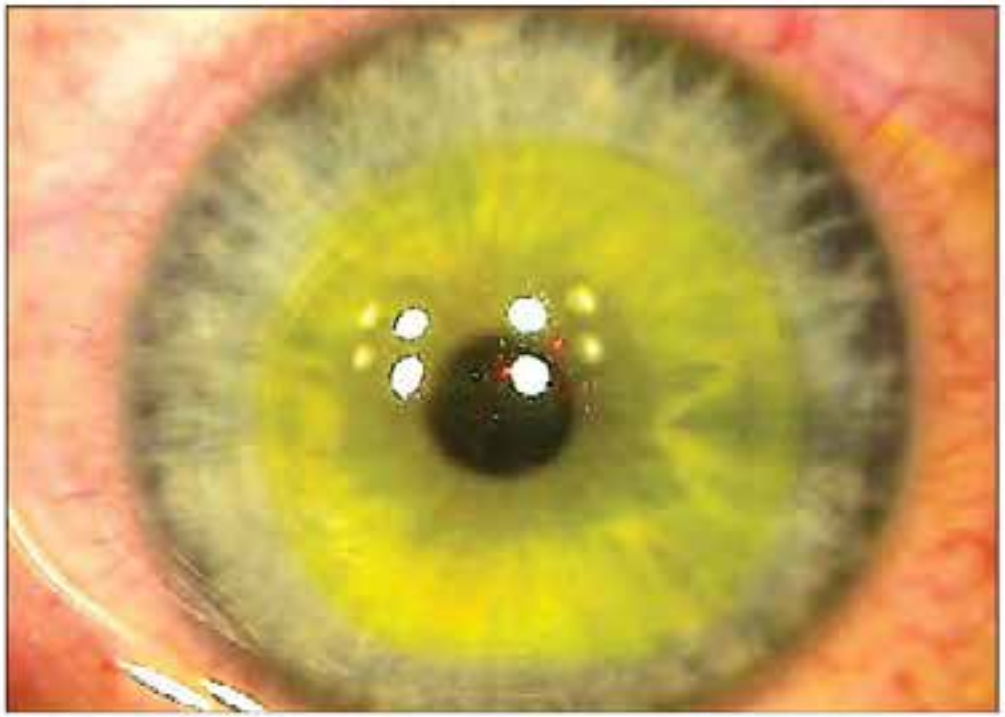

Figure 2. Repositioned LASIK flap. The yellow tinge seen within the corneal stroma is the riboflavin.

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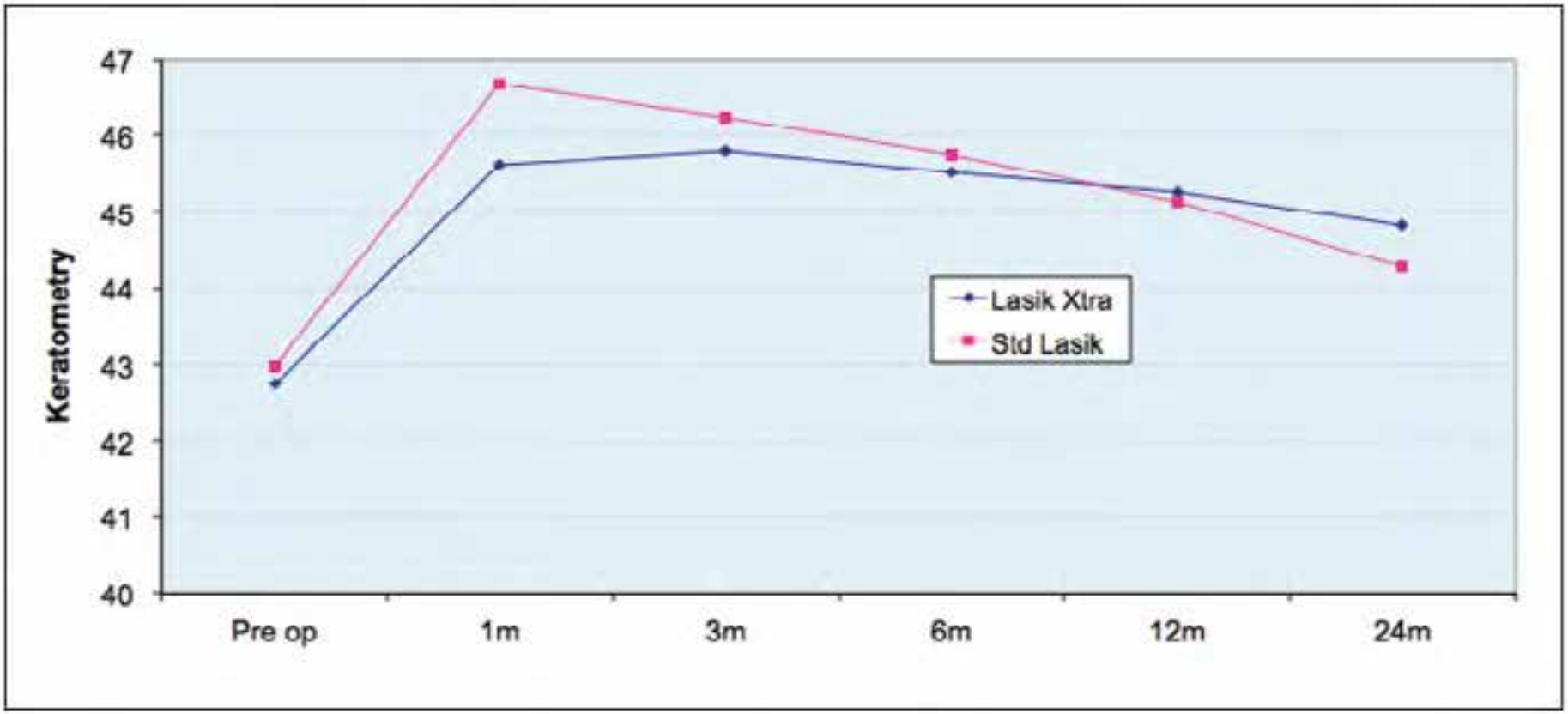

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ORIGINAL RESEARCH

Comparison of prophylactic higher fluence corneal cross-linking to control, in myopic LASIK, one year results

Anastasios John Kanellopoulos[1,2]
George Asimellis[1]
Costas Karabatsas[1]

This article was published in the following Dove Press journal:
Clinical Ophthalmology
27 November 2014
Number of times this article has been viewed

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ORIGINAL RESEARCH

Comparison of prophylactic higher fluence corneal cross-linking to control, in myopic LASIK, one year results

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George Asimellis[4]
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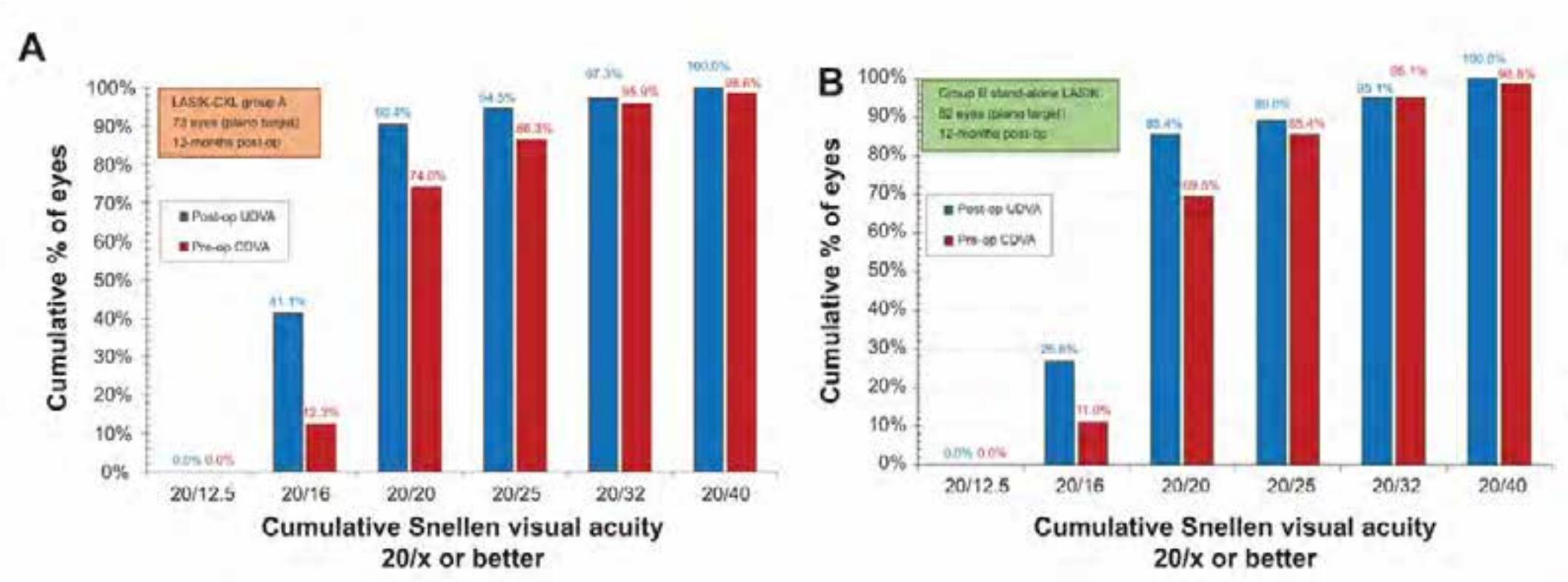


ARTICLE

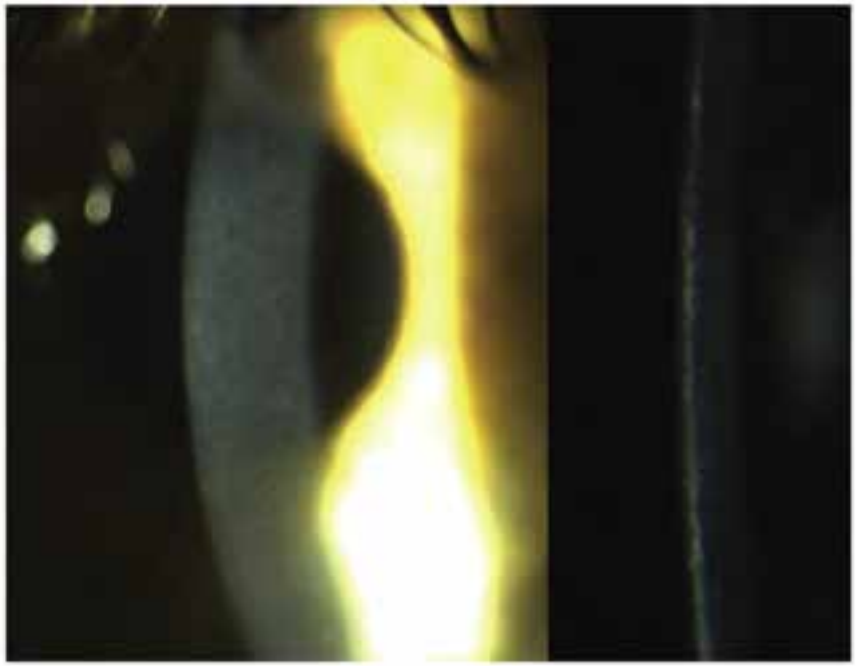
Superficial corneal crosslinking during laser in situ keratomileusis

Theo G. Seiler, MD, Isaak Fischinger, MD, Tobias Koller, MD,
Viktor Derhartunian, MD, Theo Seiler, MD, PhD

J Cataract Refract Surg 2015; 41:2165–2170

CXL eyes

Worse 1 month
Loss 1 line CDVA
DLK stage 1
DLK stage 2
Erosions



Eur J Ophthalmol. 2014 Dec 5:0. doi: 10.5301/ejo.5000543. [Epub ahead of print]

Consecutive laser in situ keratomileusis and accelerated corneal crosslinking in highly myopic patients: preliminary results.

Tan J[1], Lytle GE, Marshall J.

Author information

Abstract

PURPOSE: To report the preliminary results of an evaluation of the safety and predictability of Lasik Xtra, a technique combining laser in situ keratomileusis (LASIK) and accelerated corneal crosslinking, in highly myopic patients.

METHODS: In this consecutive comparative case series, 70 consecutive eyes undergoing LASIK for correction of high myopia (-8.00 D to -19.00 D manifest refractive spherical equivalent) were prospectively recruited and treated with Lasik Xtra and compared with a retrospective consecutive control group of 64 eyes who had undergone LASIK alone for correction of high myopia. The follow-up was 3 months. Outcome measures included uncorrected distance visual acuity (UDVA), corrected distance visual acuity (CDVA), and refraction.

RESULTS: A total of 61% of LASIK only eyes achieved UDVA of 20/25 or better, compared to 98% of Lasik Xtra eyes (p<0.001) at 3 months. A greater percentage of eyes were within ±0.50 of the intended correction in the Lasik Xtra group (88%) than in the LASIK only group (65%) at 3 months (p = 0.005). Linear regression of the scatterplot of attempted versus achieved correction reveals a coefficient of determination of 0.83 in the LASIK only group vs 0.99 in the Lasik Xtra group. A trend (p = 0.051) towards greater refractive drift in the LASIK group (-0.13 D) vs the Lasik Xtra group (-0.04 D) was observed. No adverse events were observed in either group.

CONCLUSIONS: Lasik Xtra did not reduce the refractive accuracy of the LASIK procedure. The addition of crosslinking may induce early stabilization of the cornea after LASIK, improving the predictability of refractive outcomes in highly myopic subjects.

ORIGINAL ARTICLE

Short-term Variance of Refractive Outcomes After Simultaneous LASIK and High-Fluence Cross-linking in High Myopic Correction

Tommy C. Y. Chan, FRCS; Marco C. Y. Yu, PhD; Alex L. K. Ng, MRCS; George P. M. Cheng, FRCS; Jiamei Zhang, MD; Yan Wang, MD; Vishal Jhanji, MD, FRCOphth

JRS. 2016 Oct; 32:664-670.

USC Roski Eye Institute
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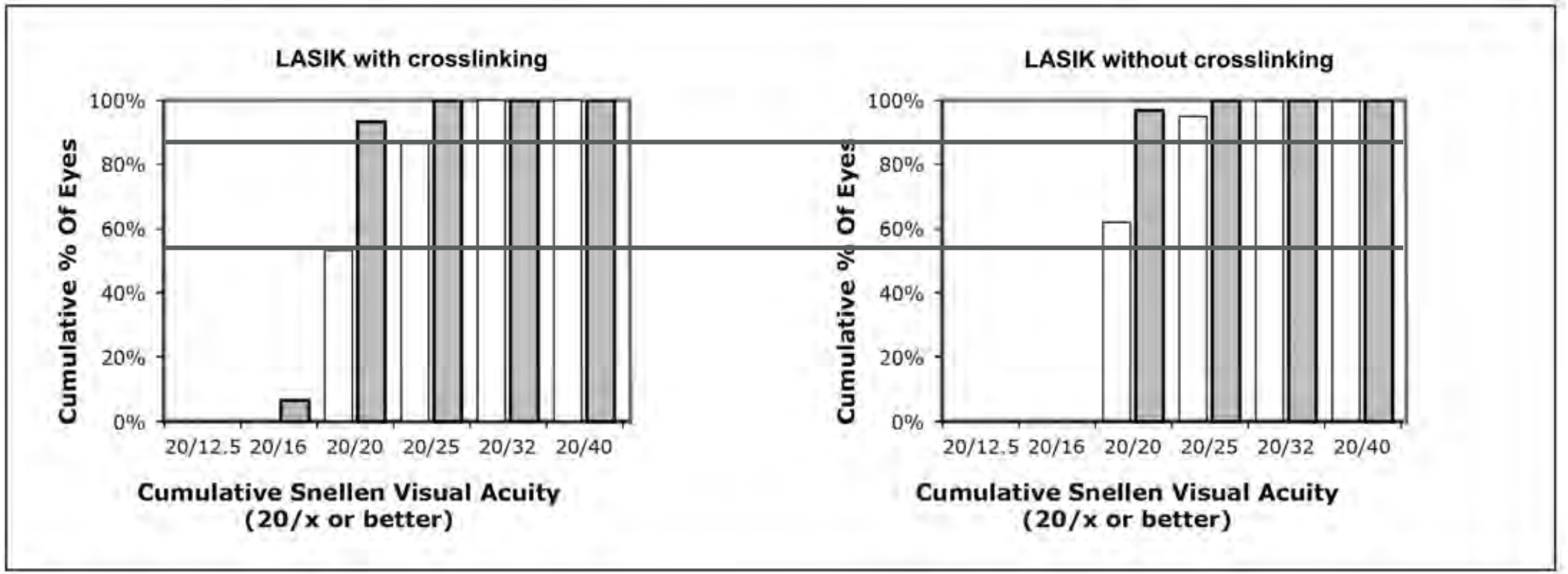

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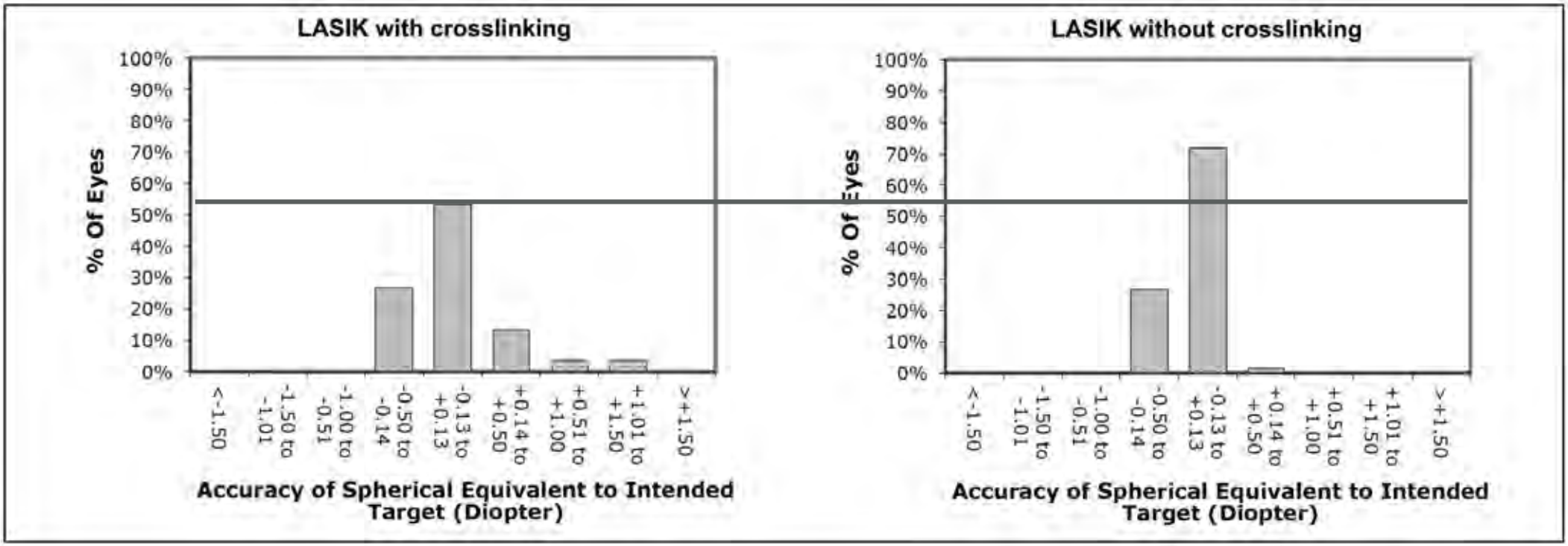

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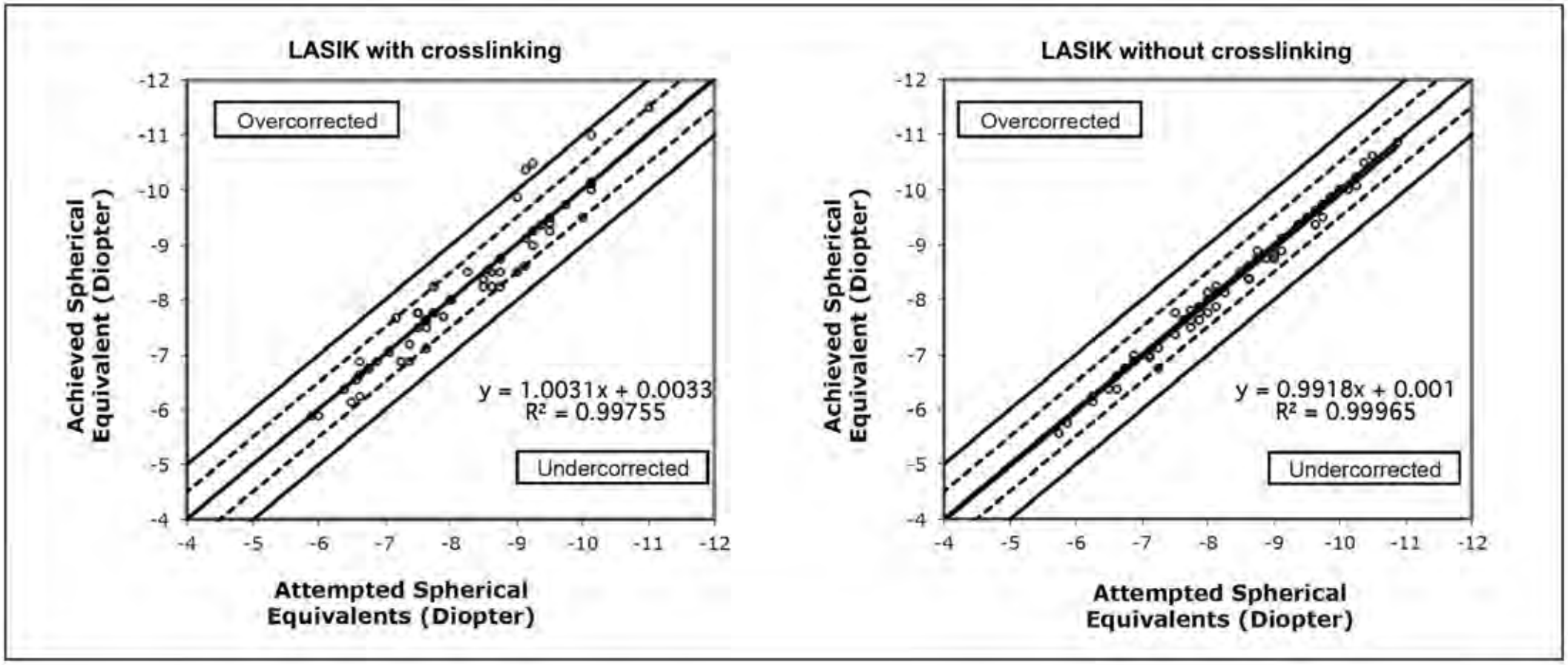
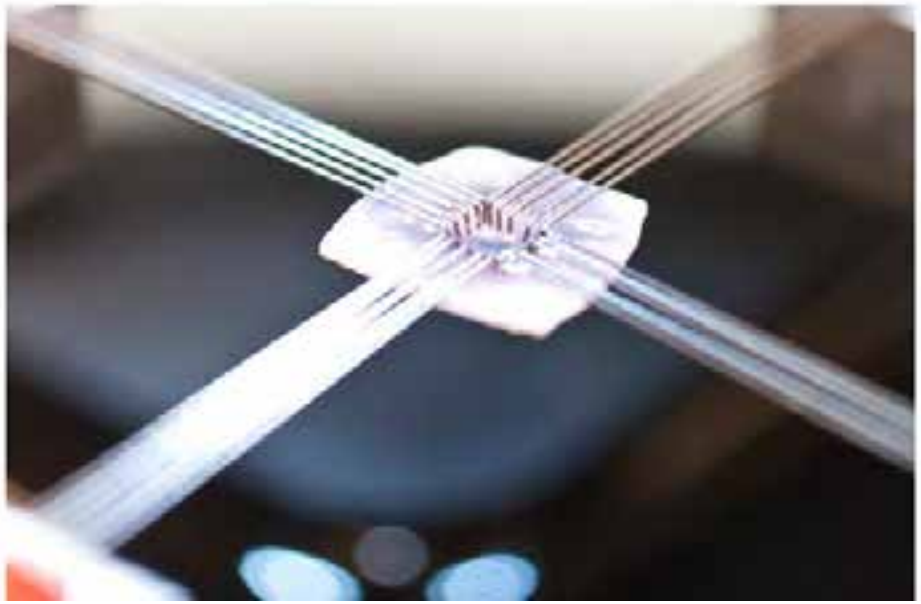


High-irradiance CXL combined with myopic LASIK: flap and residual stroma biomechanical properties studied ex-vivo

Anastasios John Kanellopoulos,[1,2] George Asimellis,[1] Borja Salvador-Culla,[3] James Chodosh,[3] Joseph B Ciolino[3]

BJO Online First, published on March 20, 2015 as 10.1136/bjophthalmol-2014-306411



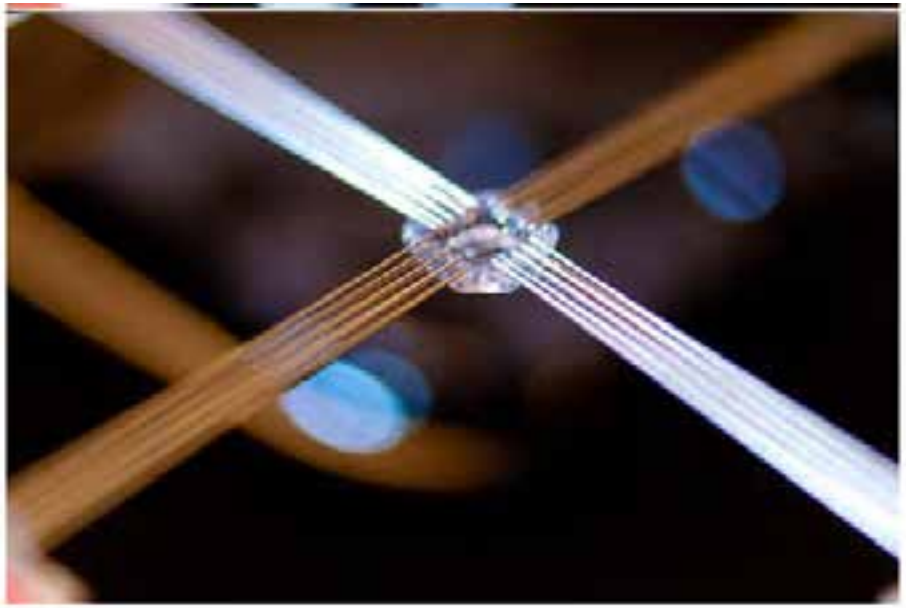


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Table 2 Biomechanical comparative measurements between the two groups

	Stress	Units: kPa			Young's shear modulus	Units: MPa		
	@ 10% strain		@ 20% strain		@ 10% strain		@ 20% strain	
Group A (control)	158.3	±16.8	1566.6	±45.9	5.9	±3.9	13.6	±6.2
Group B (CXL)	182.8	±20.8	1534.5	±134.8	6.5	±3.2	11.9	±4.1
Δ	15%		−2%		11%		−12%	
p	0.084		0.140		0.095		0.089	
t	−2.07		+1.7		−1.98		+2.02	

Δ, relative (%) difference between metrics; p, Student t test p value; t, Student t test t value. Results from flap specimens.

Brillouin Microscopy can Measure Corneal Biomechanics

Brillouin Microscopy for Corneal Biomechanics

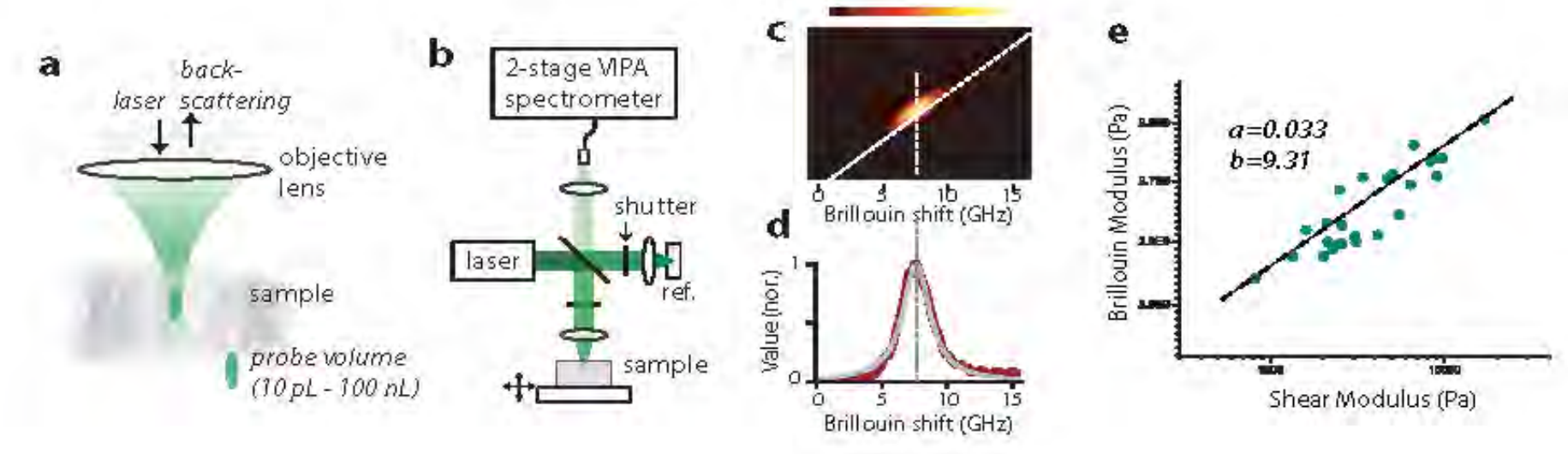
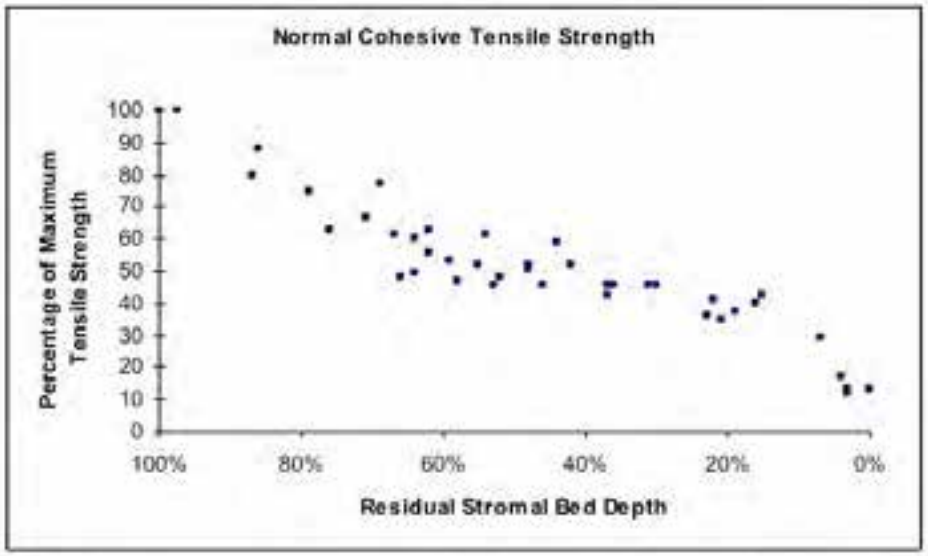
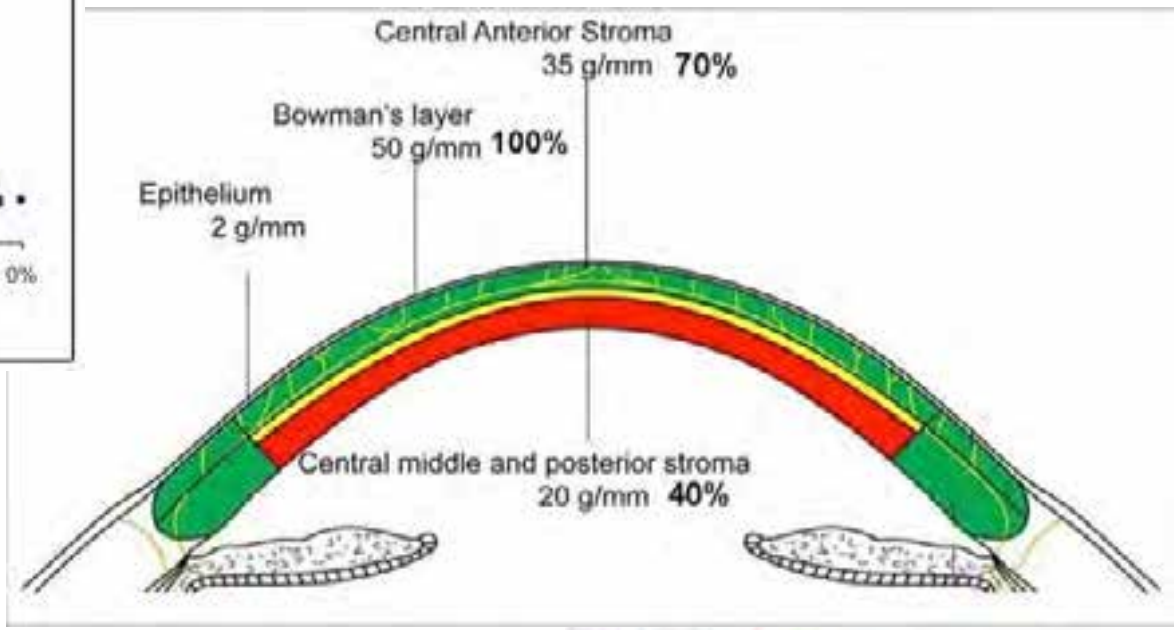


Fig. 3: Brillouin microscopy. (a) Back-scattered light acquires a frequency shift due to interaction of incident light with phonons in the sample. (b) The scattered light is collected by a confocal microscope and analyzed by a home-built high-resolution spectrometer. (c) CCD spectrometer output shows Brillouin spectrum of corneal stroma. (d) Analysis of the Brillouin spectrum (red) with Lorentzian curve fit (gray). (e) Log-log correlation between Brillouin and shear modulus of corneal tissue.

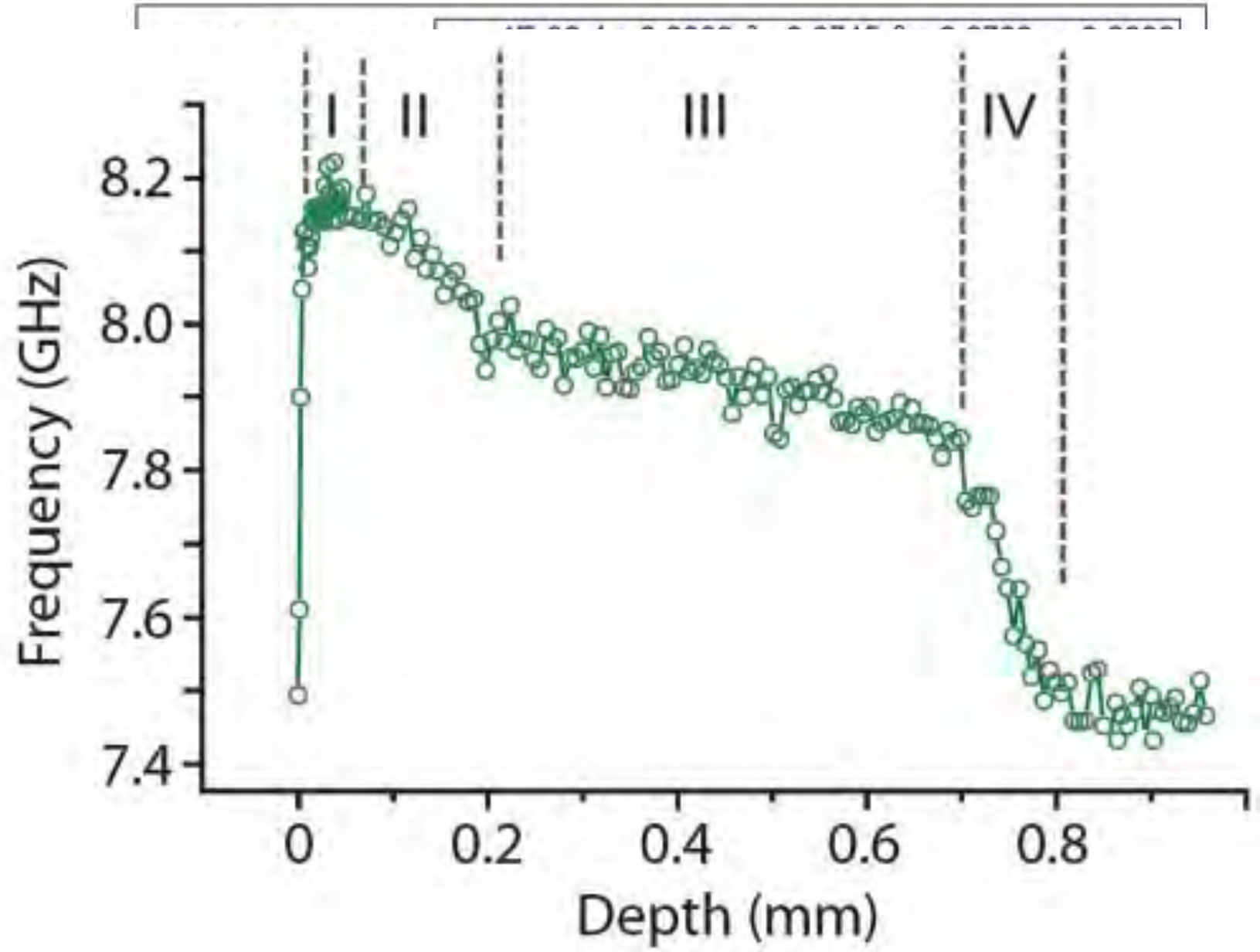
Depth-dependent Cohesive Tensile Strength in Human Donor Corneas: Implications for Refractive Surgery

J. Bradley Randleman, MD; Daniel G. Dawson, MD; Hans E. Grossniklaus, MD; Bernard E. McCarey, PhD; Henry F. Edelhauser, PhD





JRS 2008: S85-S89


I
II
III
IV
8.2
8.0
7.8
7.6
7.4
Frequency (GHz)
0
0.2
0.4
0.6
0.8
Depth (mm)

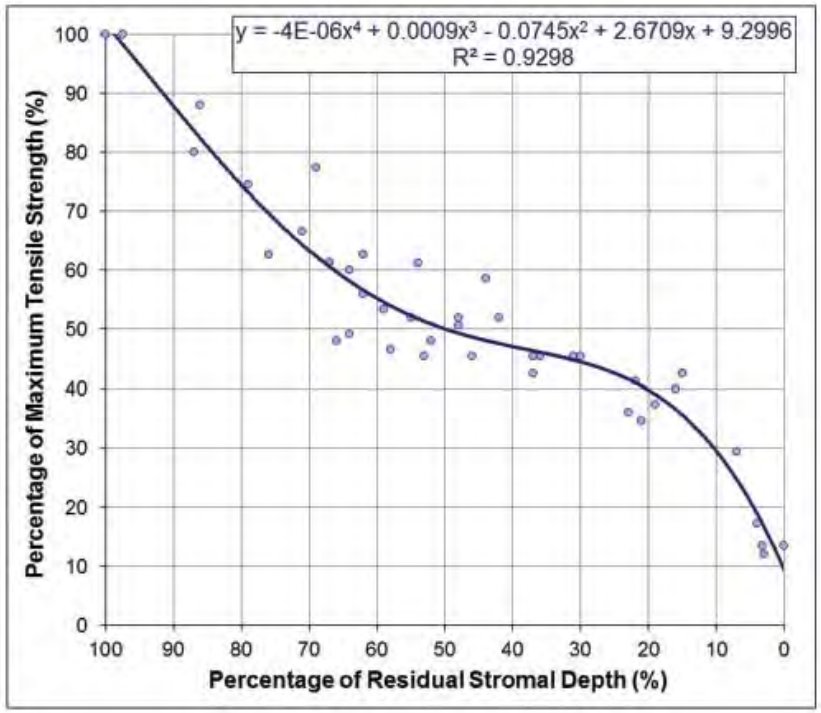
ORIGINAL ARTICLE

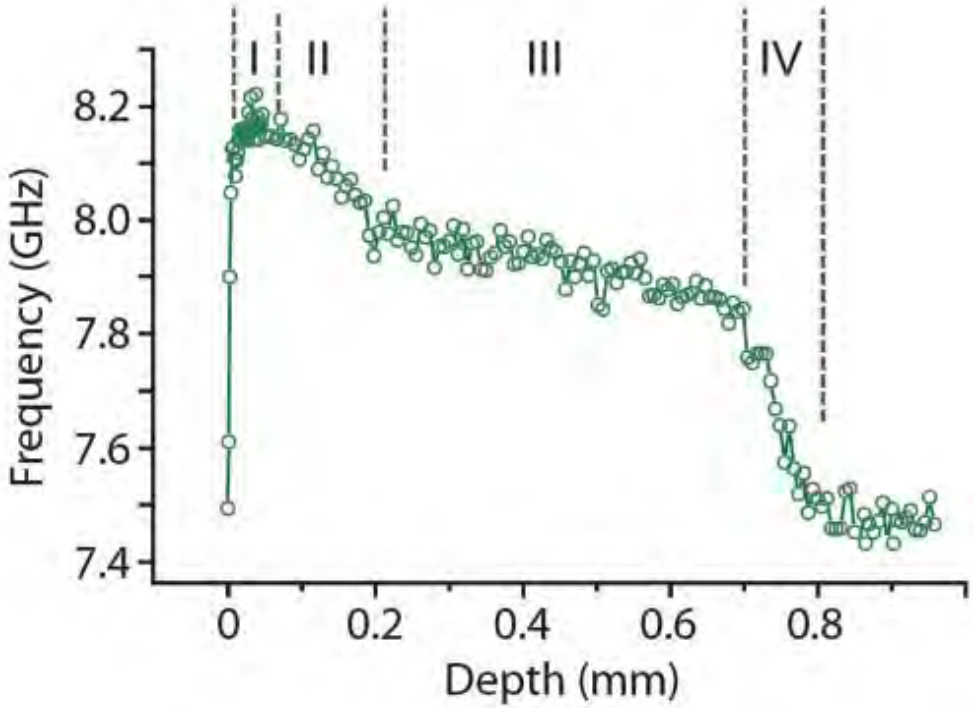
Mathematical Model to Compare the Relative Tensile Strength of the Cornea After PRK, LASIK, and Small Incision Lenticule Extraction

Dan Z. Reinstein, MD, MA(Cantab), FRCOphth; Timothy J. Archer, MA(Oxon), DipCompSci(Cantab); J. Bradley Randleman, MD

J Refract Surg. 2013:454-460

Scarcelli G, Pineda R, Yun SH. IOVS 2012:185-190





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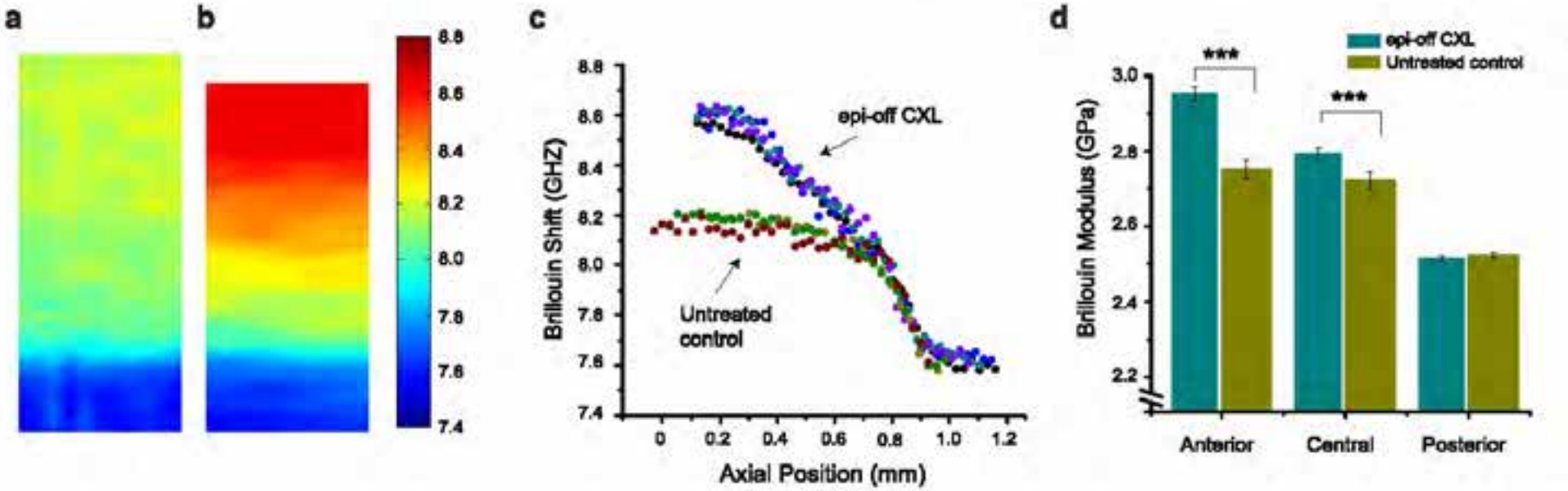
Cornea

Brillouin Microscopy of Collagen Crosslinking: Noncontact Depth-Dependent Analysis of Corneal Elastic Modulus

Giuliano Scarcelli,[1,2] Sabine Kling,[3] Elena Quijano,[1] Roberto Pineda,[4] Susana Marcos,[3] and Seok Hyun Yun[1,2,5]

(*Invest Ophthalmol Vis Sci.* 2013;54:1418–1425)



Brillouin can measure differences before & after CXL and between different CXL techniques

Purpose

- To determine the impact of an accelerated corneal cross-linking protocol on corneal biomechanics as measured by Brillouin microscopy in porcine eyes.

Methods

- Ten porcine eyes had LASIK flaps created using the Amadeus II mechanical microkeratome and then subjected to accelerated corneal cross-linking (A-CXL)
  - Ultraviolet-A (UVA) fluence of 30 mW/cm2
  - 80 seconds (total energy 2.4 J/cm2)
  - VibeX Xtra riboflavin solution (Avedro, Inc.)
    - 0.22% riboflavin, isotonic

- Brillouin microscopy was performed before and after flap creation and after A-CXL

Results

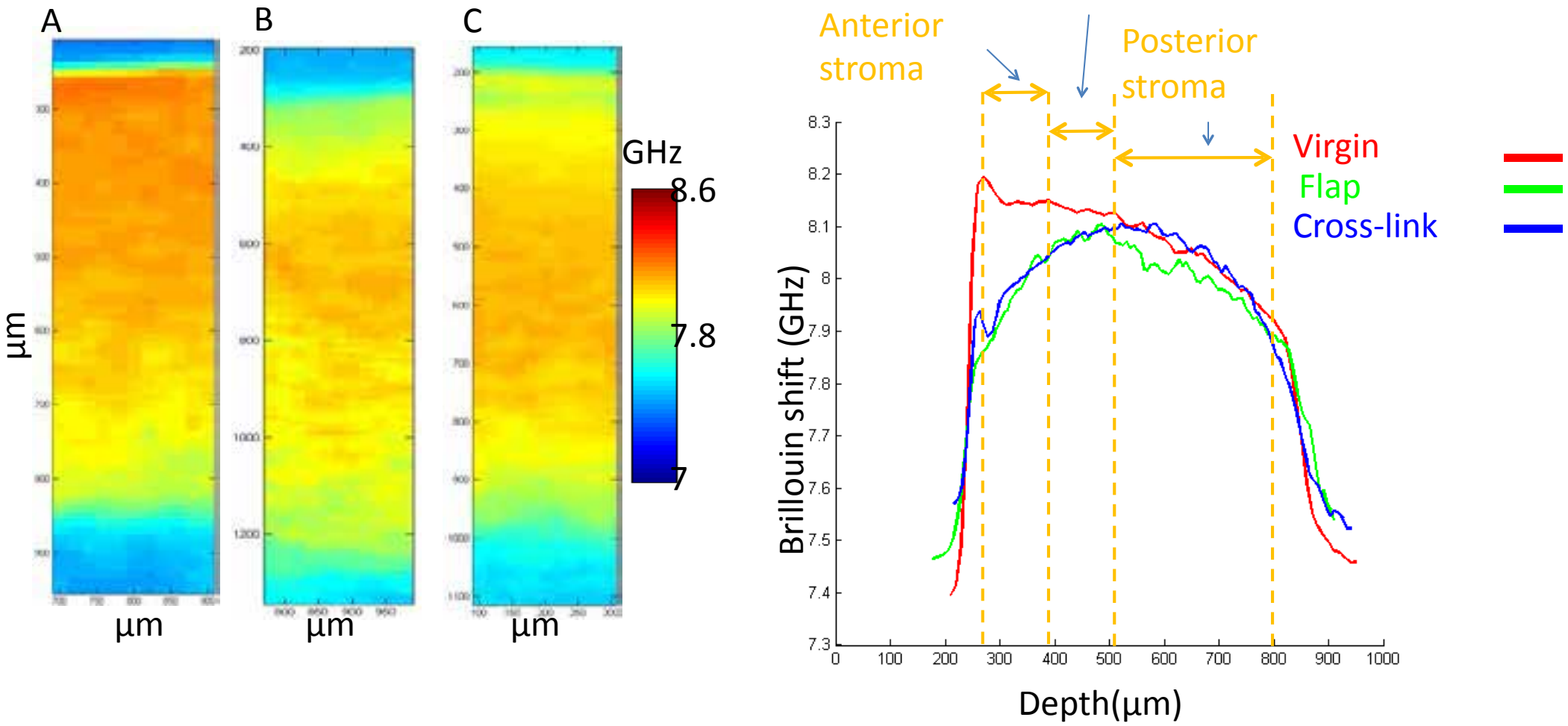
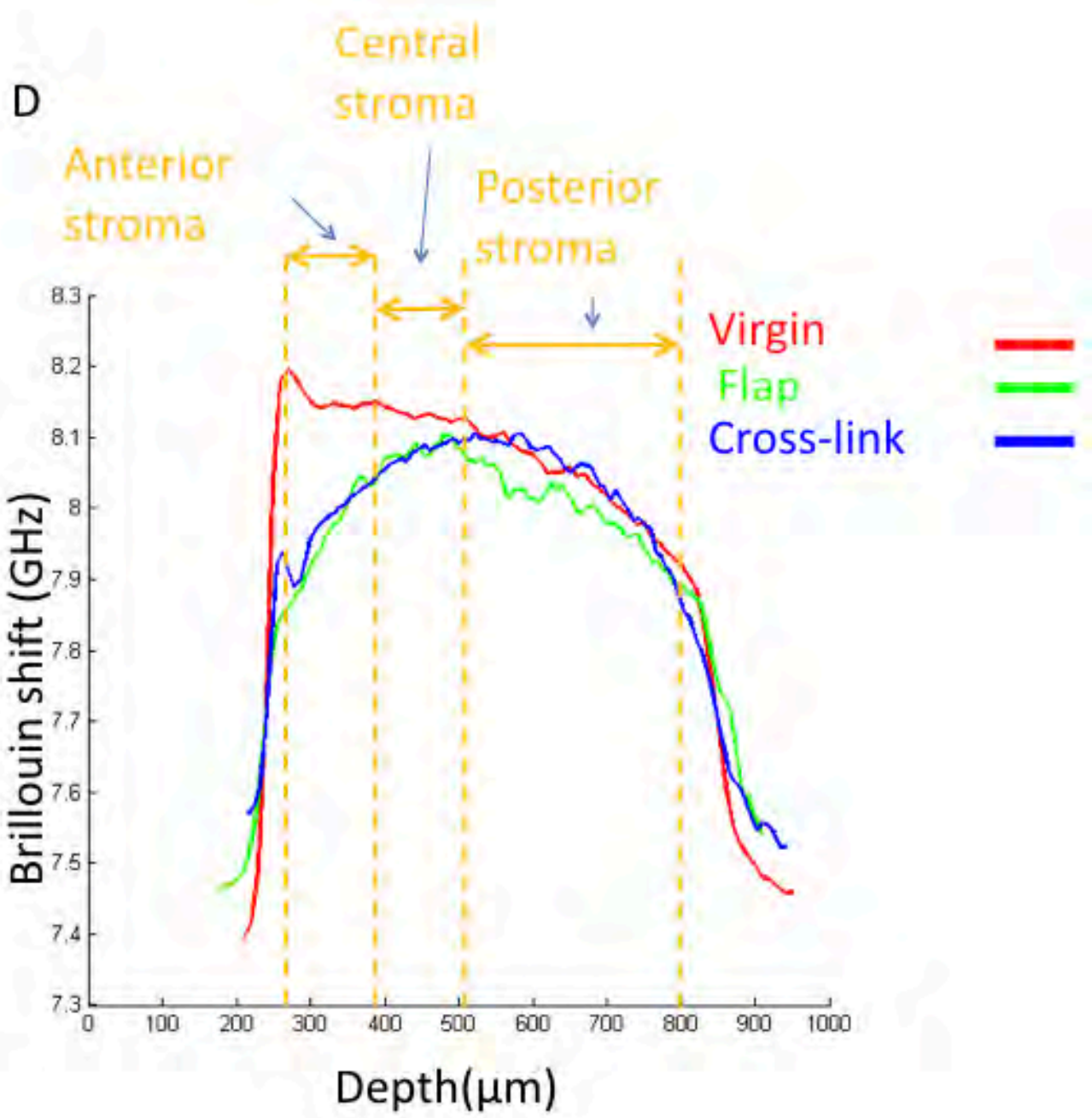


Figure 1.Brillouin shift characterization of the standard Flap-CXL procedure. (A) Representative cross-sectional Brillouin image of virgin porcine cornea. (B) Brillouin image of cornea after flap creation with mechanical microkeratome. (C) Brillouin image of cornea after standard CXL. (D) Brillouin depth profiles of the virgin (red line), flap only (green only) and after flap and rapid cross-linking (blue line).

Results



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Significant reduction after flap creation
No significant difference with A-CXL

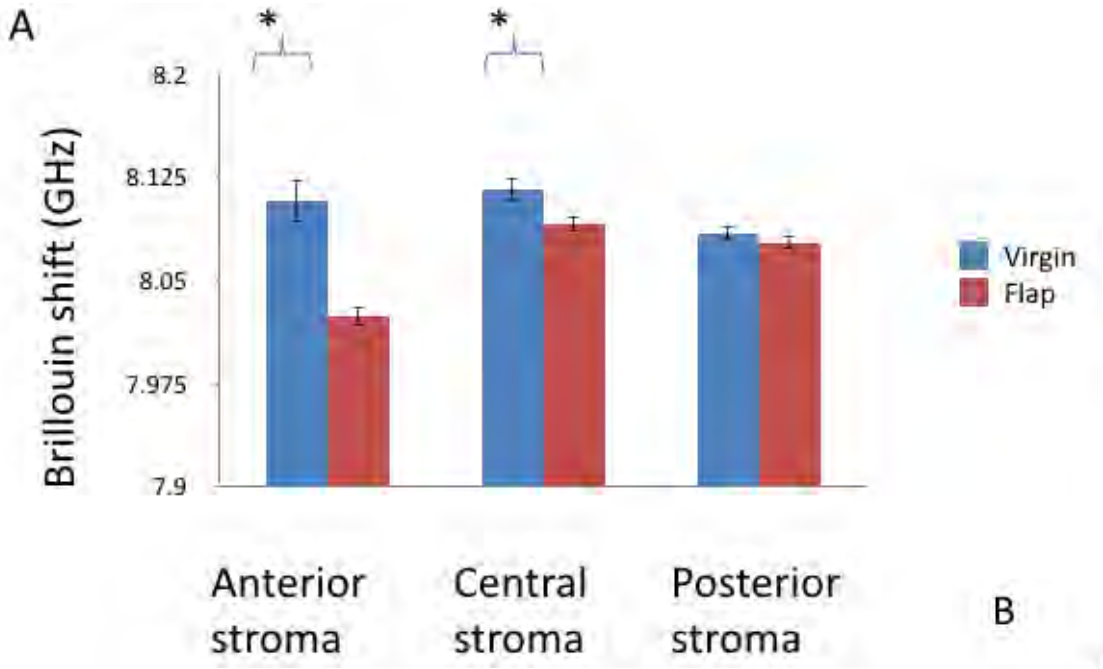
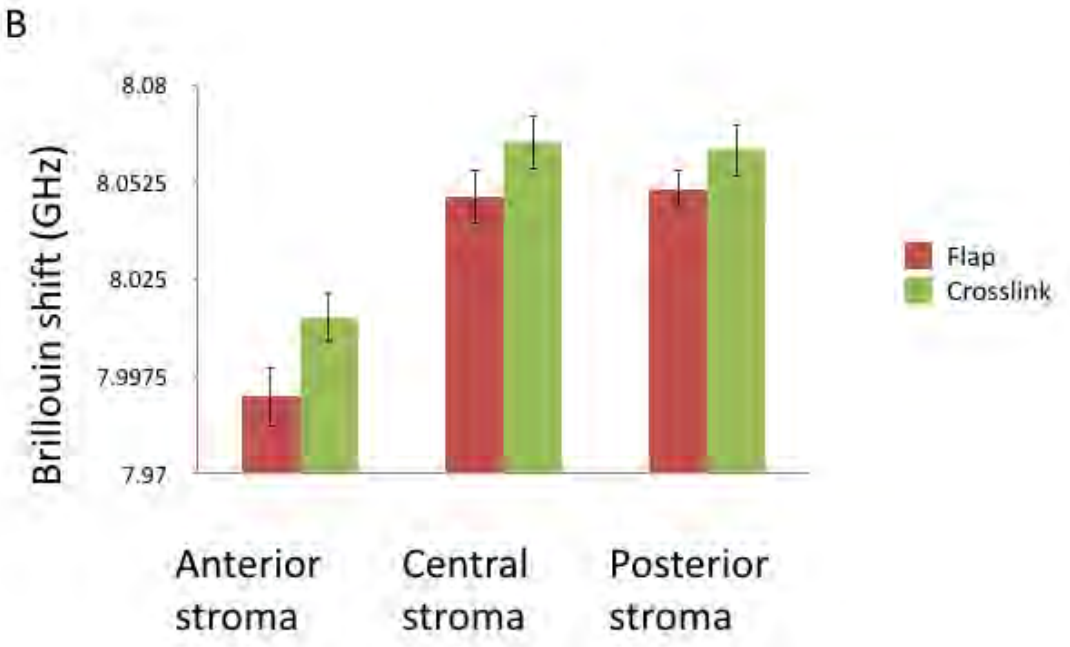


Figure A
Significant reduction after flap creation in anterior and central stroma only

Figure B
no significant change after A-CXL in any region



Conclusions

- Flap creation significantly reduces corneal stiffness in the anterior third of the porcine cornea.

- Accelerated CXL did not have any significant biomechanical impact on the porcine cornea at any depth

Thank You

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