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Corneal strain induced by intrastromal corneal ring segment visualized with the novel optical coherence elastography

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Sabine Kling PhD



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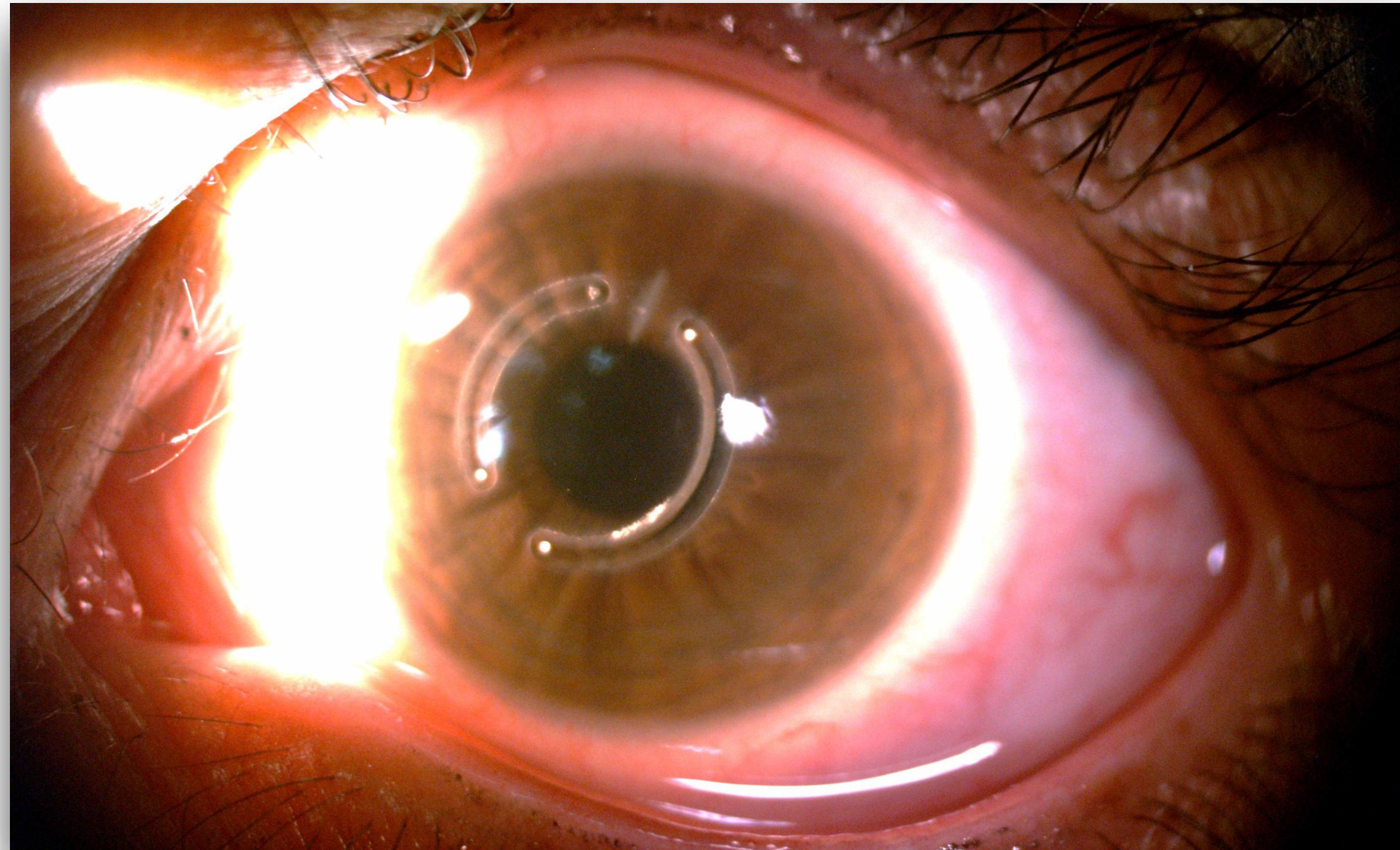
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Intracorneal ring segments

1. Background





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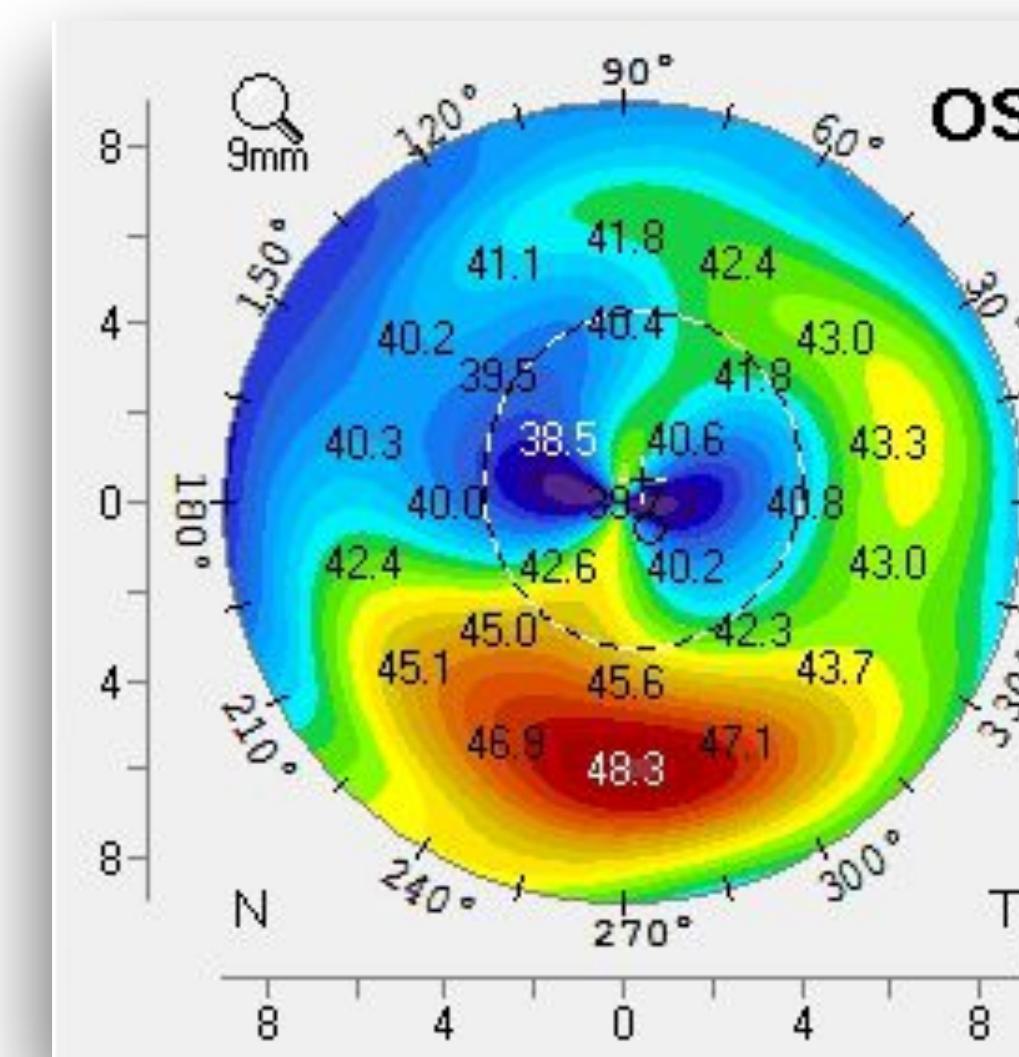
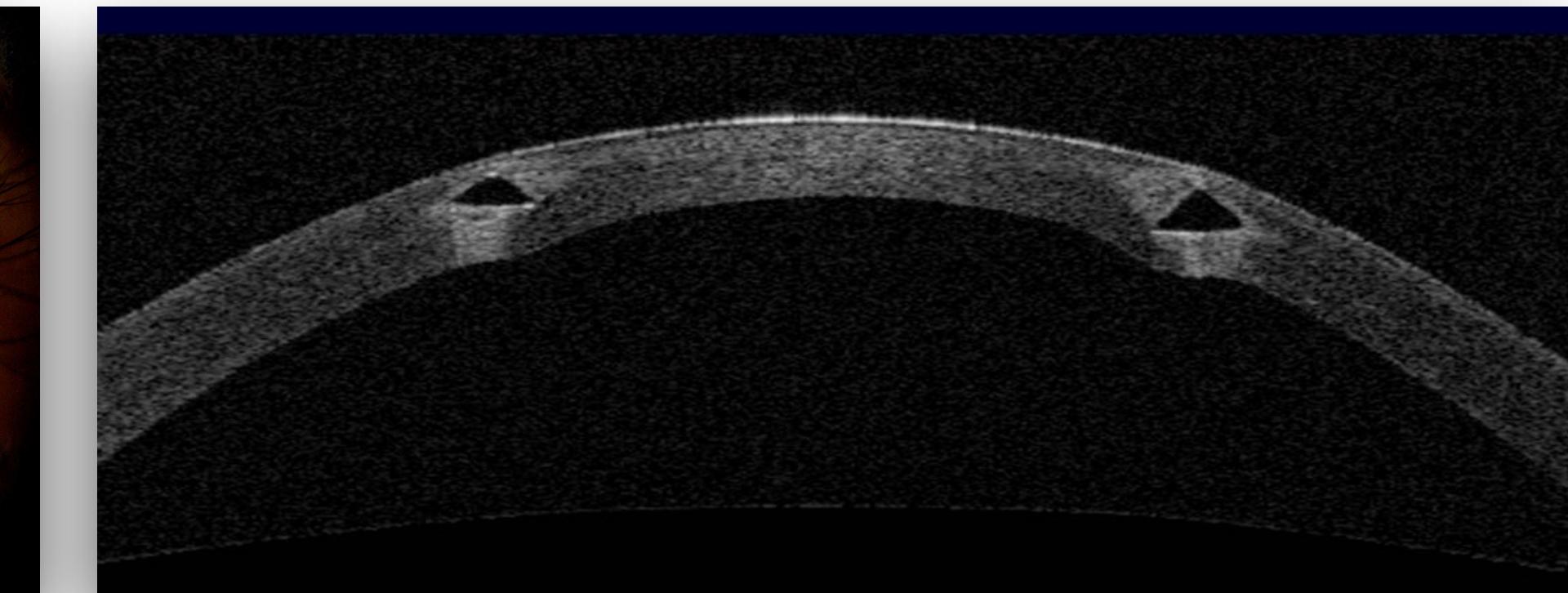
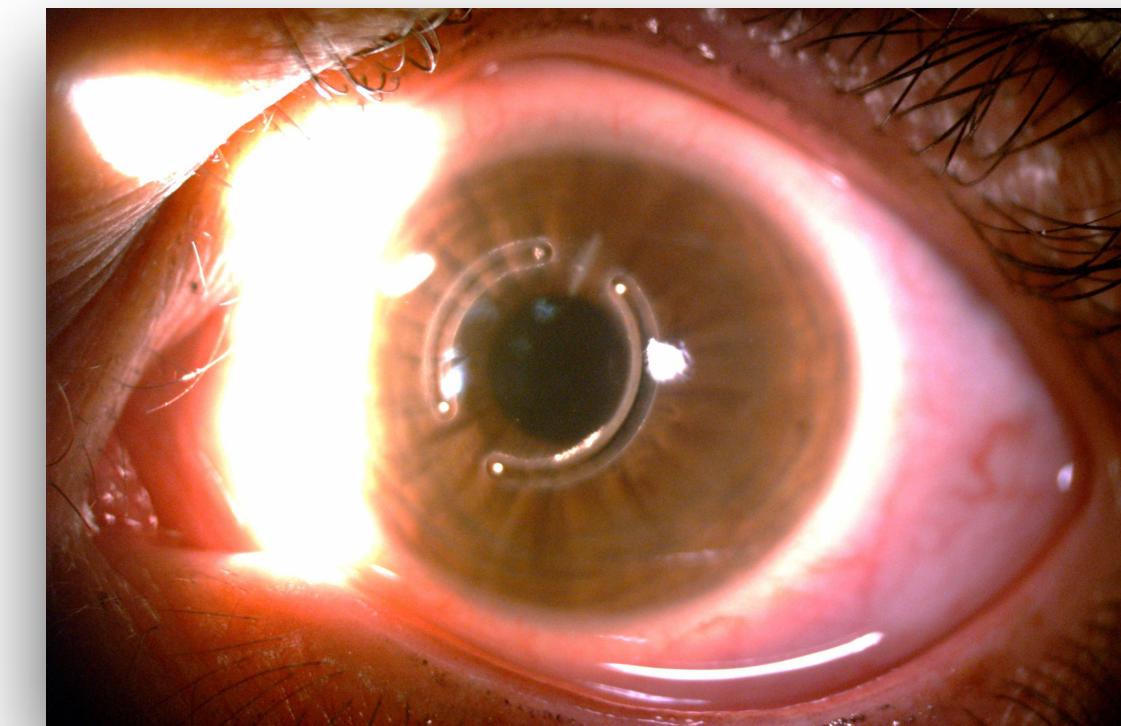
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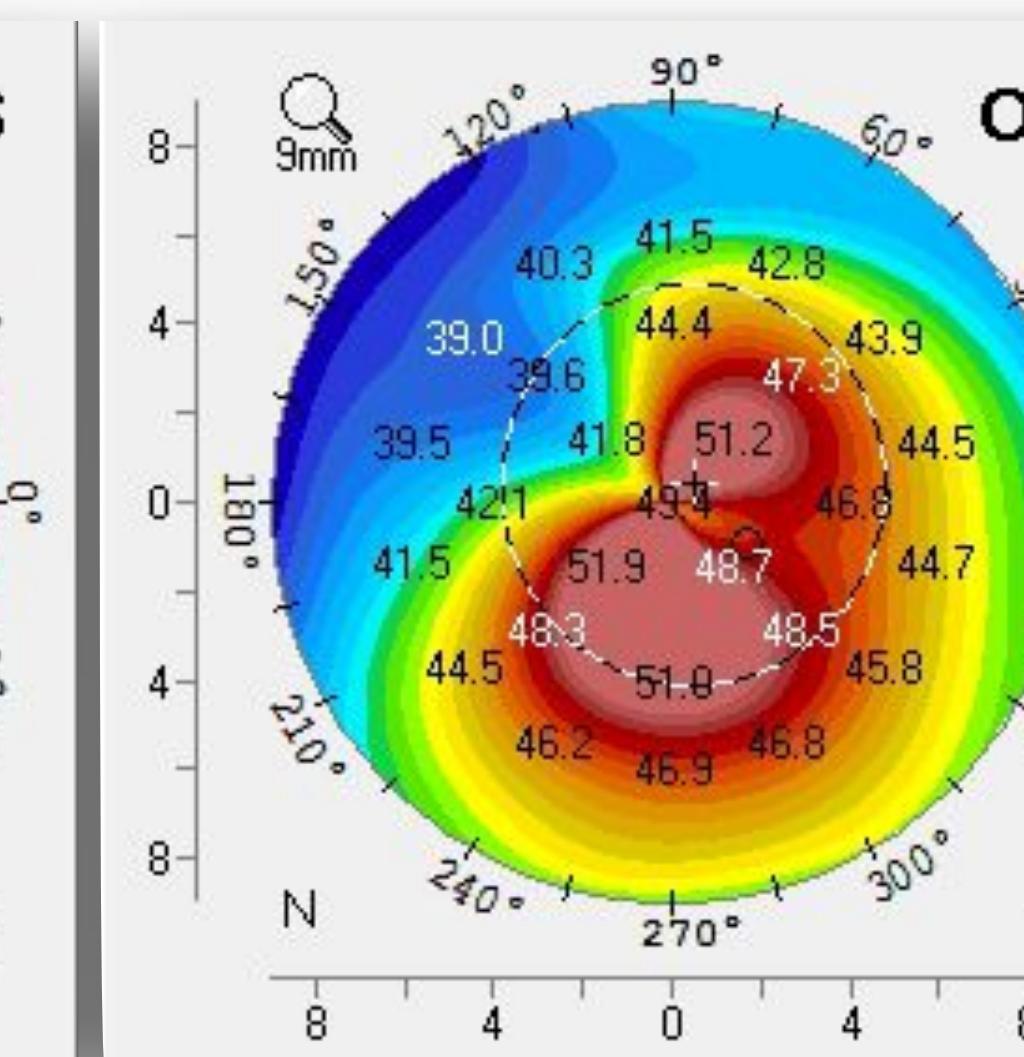
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1. Background

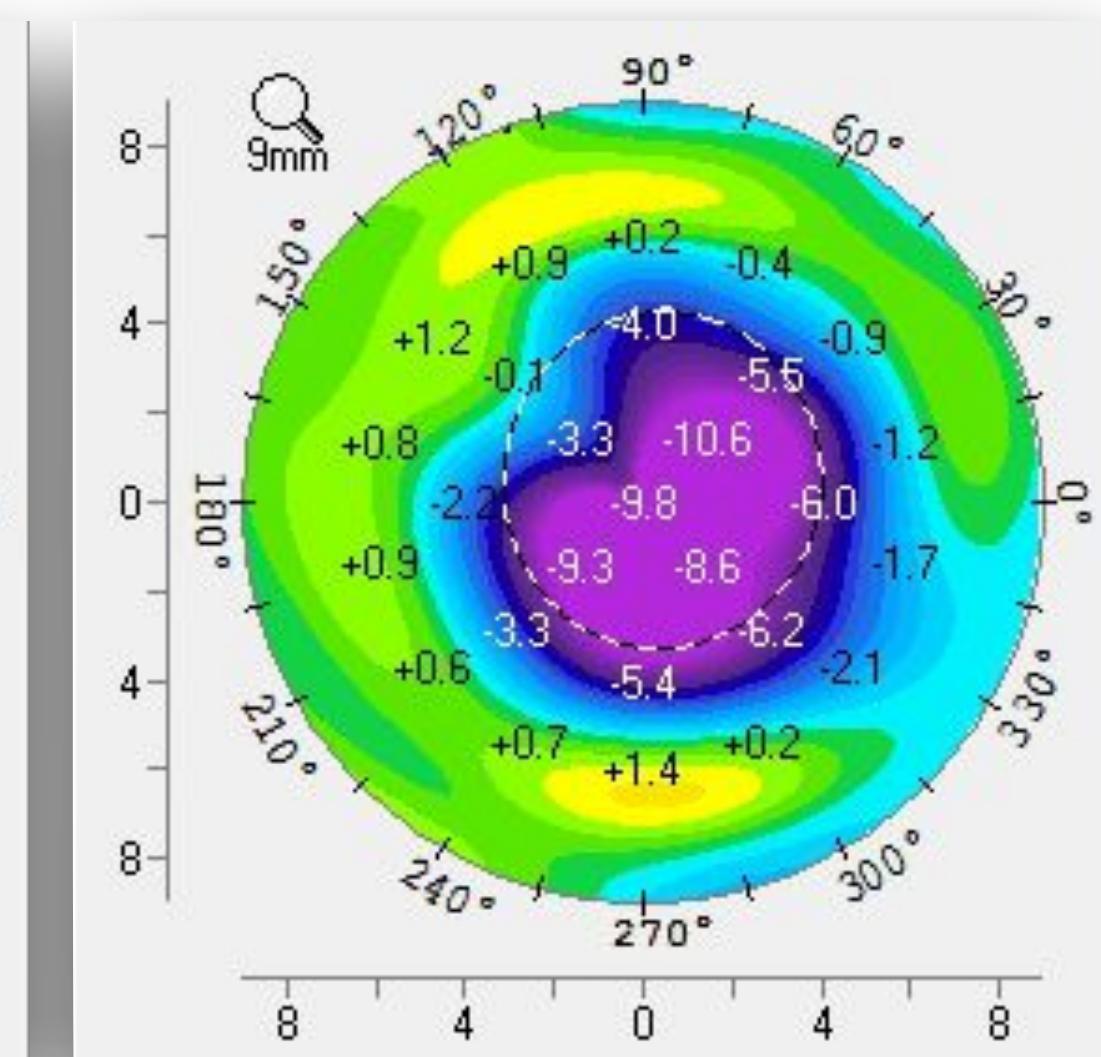
Intracorneal ring segments selectively flatten the cornea



After ICRS



Before ICRS



Diff



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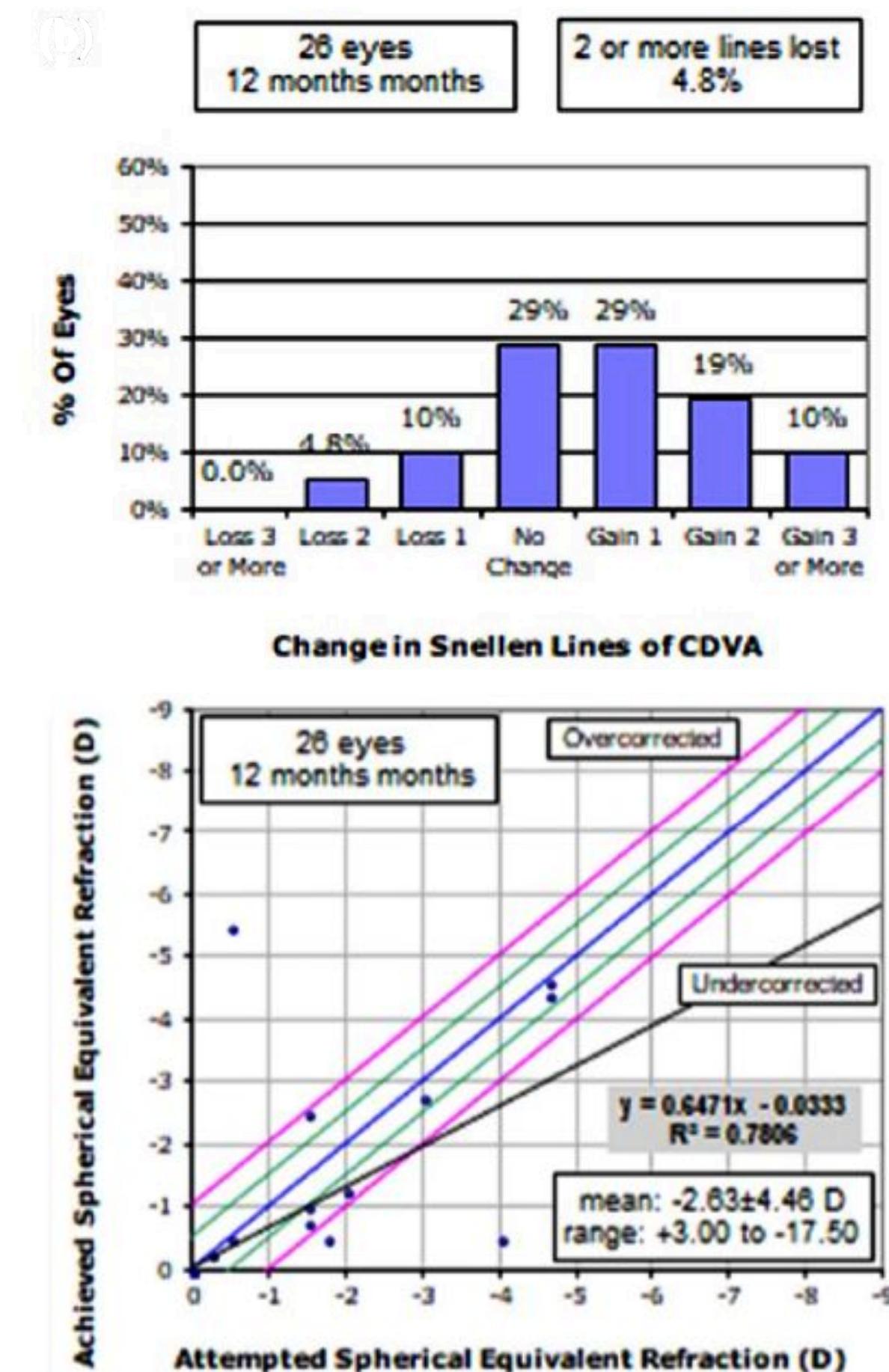
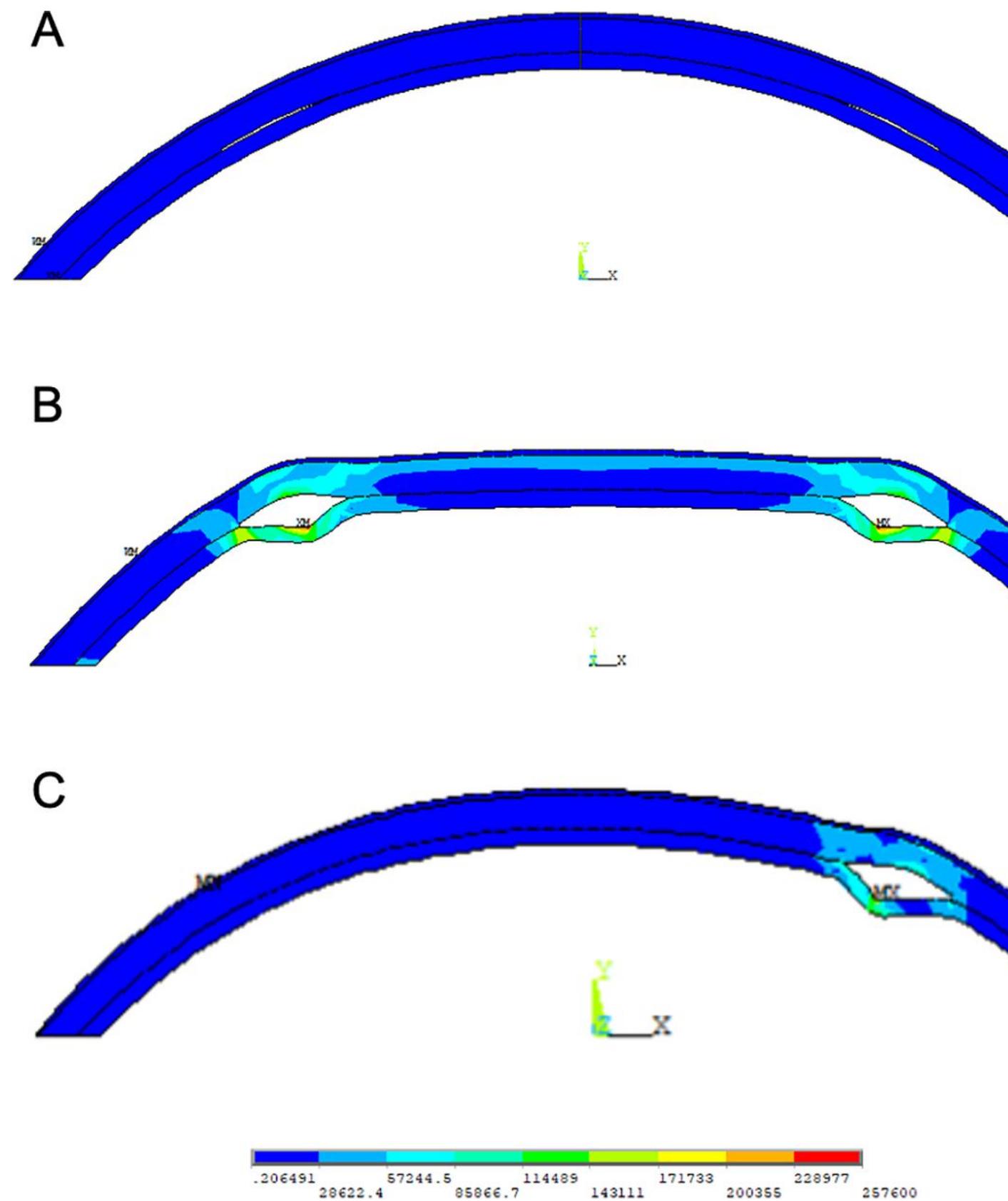
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1. Background

Additive Surgery

Predictable ?



Oteyza et al, PLoS One 2021

Peris-Martinez, EJO 2020

Guell, Curr Opin Ophthalmol, 2015



1. Background

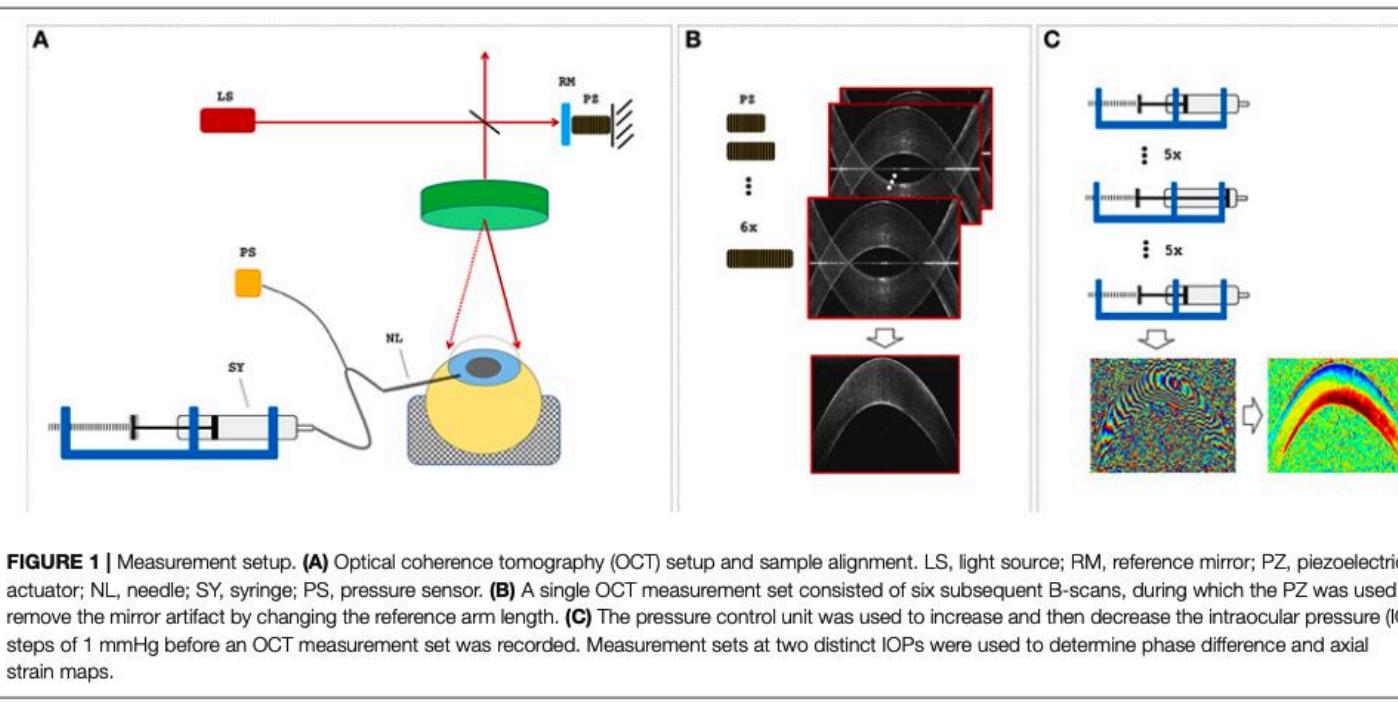


FIGURE 1 | Measurement setup. **(A)** Optical coherence tomography (OCT) setup and sample alignment. LS, light source; RM, reference mirror; PZ, piezoelectric actuator; NL, needle; SY, syringe; PS, pressure sensor. **(B)** A single OCT measurement set consisted of six subsequent B-scans, during which the PZ was used to remove the mirror artifact by changing the reference arm length. **(C)** The pressure control unit was used to increase and then decrease the intraocular pressure (IOP) in steps of 1 mmHg before an OCT measurement set was recorded. Measurement sets at two distinct IOPs were used to determine phase difference and axial strain maps.

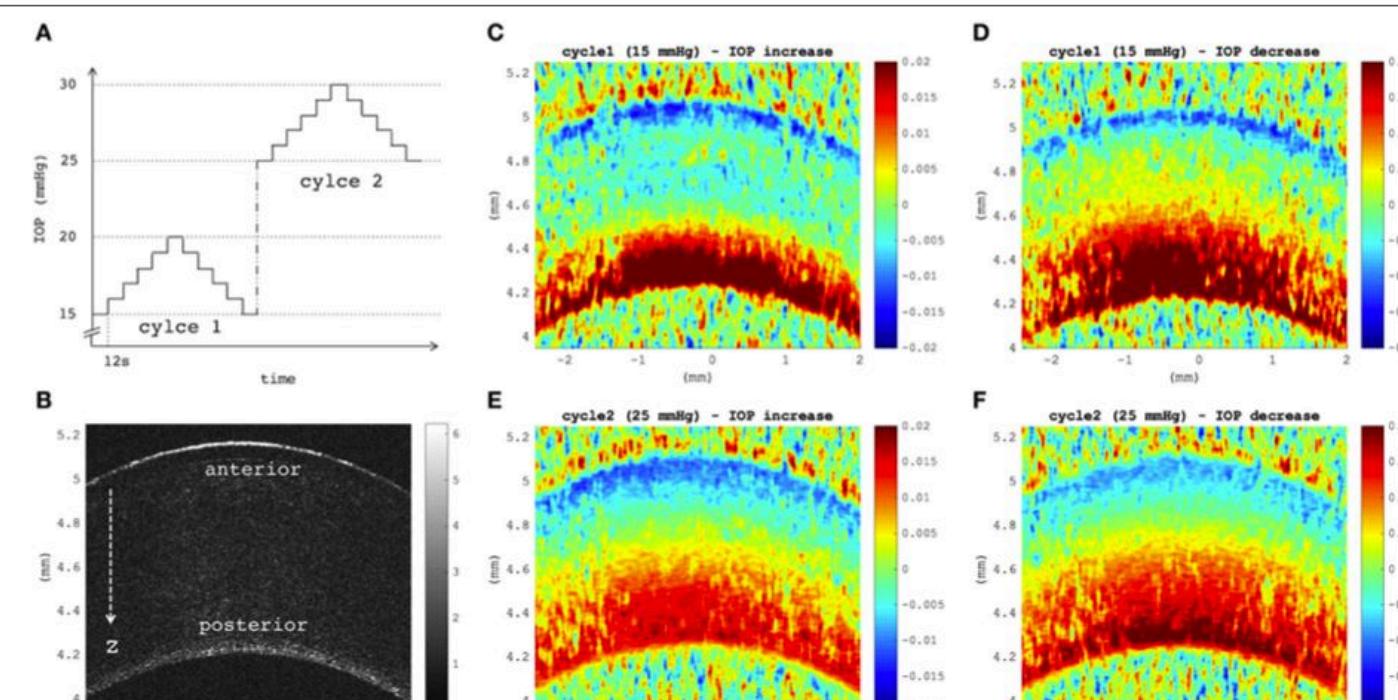
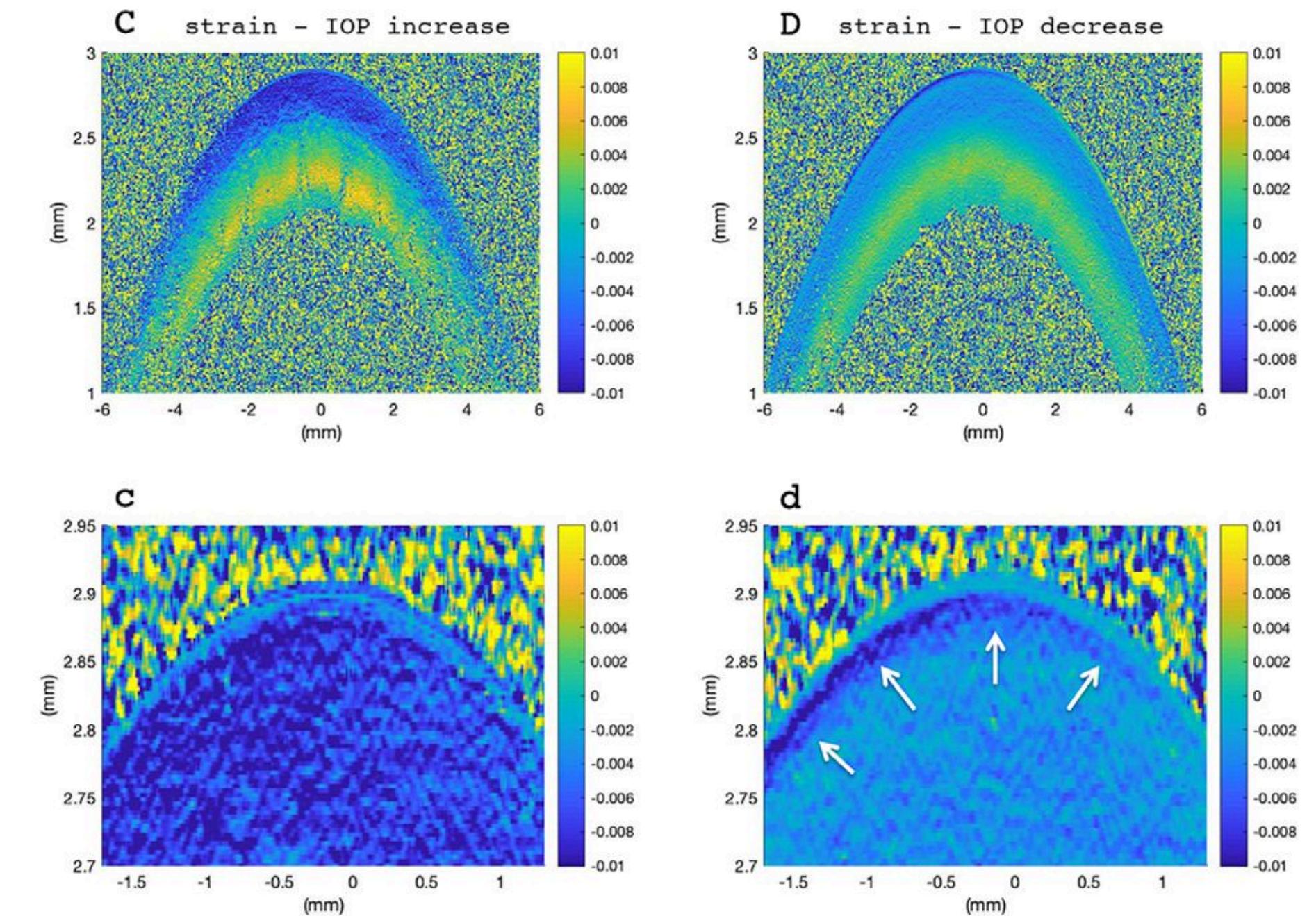


FIGURE 4 | **(A)** Intracocular pressure (IOP) modulation sequence consisting of two subsequent cycles of pressure increase/decrease with reference to initial IOPs of 15 mmHg (cycle 1) and 25 mmHg (cycle 2). **(B)** B-mode morphological image indicating anterior and posterior corneal surfaces, as well as the axial direction z of optical coherence tomography (OCT) imaging. **(C–F)** Axial strain induced by a variation of 5 mmHg, obtained by summing over strains retrieved from five subsequent pressure steps of 1 mmHg (**C,E**) during eye inflation and (**D,F**) during deflation. Strain maps at a lower initial IOP showed a larger tension of the posterior stroma than at a higher initial IOP (**D** vs. **F**). Posterior tension was higher during IOP decrease than during increase, independent of the initial IOP. Postmortem time at the time of measurement was ~3 h + 3 h:38 min.

Quasi-Static Optical Coherence Elastography to Characterize Human Corneal Biomechanical Properties

Sabine Kling,¹ Emilio A. Torres-Netto,^{2,3,5} Bogdan Spiru,⁴ Walter Sekundo,⁴ and Farhad Hafezi^{2,5,7}



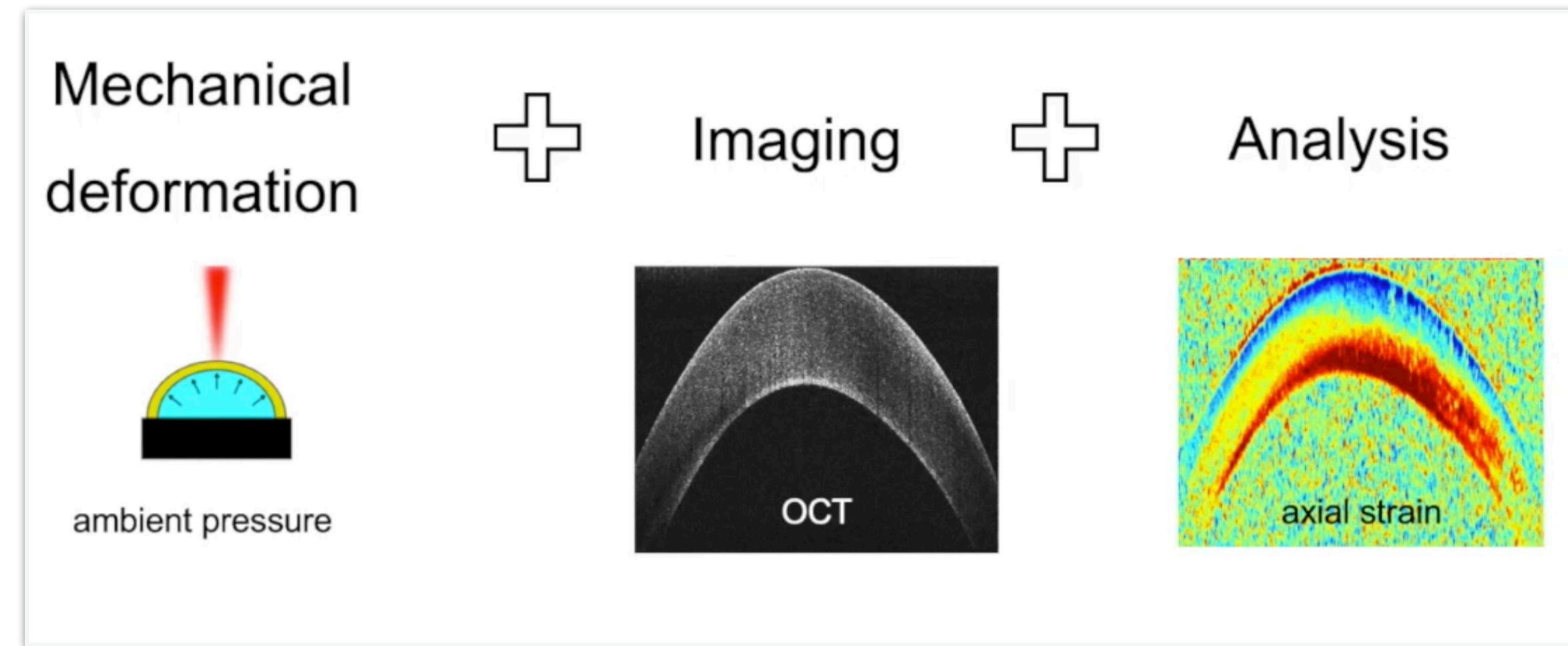


1. Background

2. Purpose

Purpose

To evaluate the axial **strain field** directly after creating a stromal tunnel and implanting an **intracorneal ring segment (ICRS)** using **OCT-Elastography**





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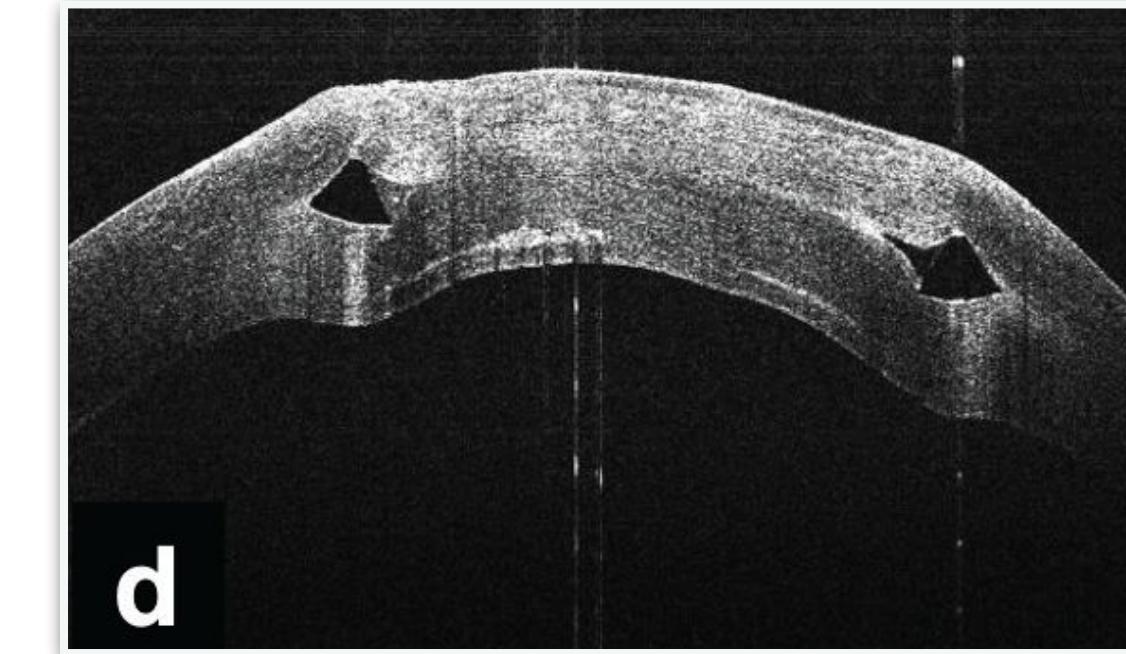


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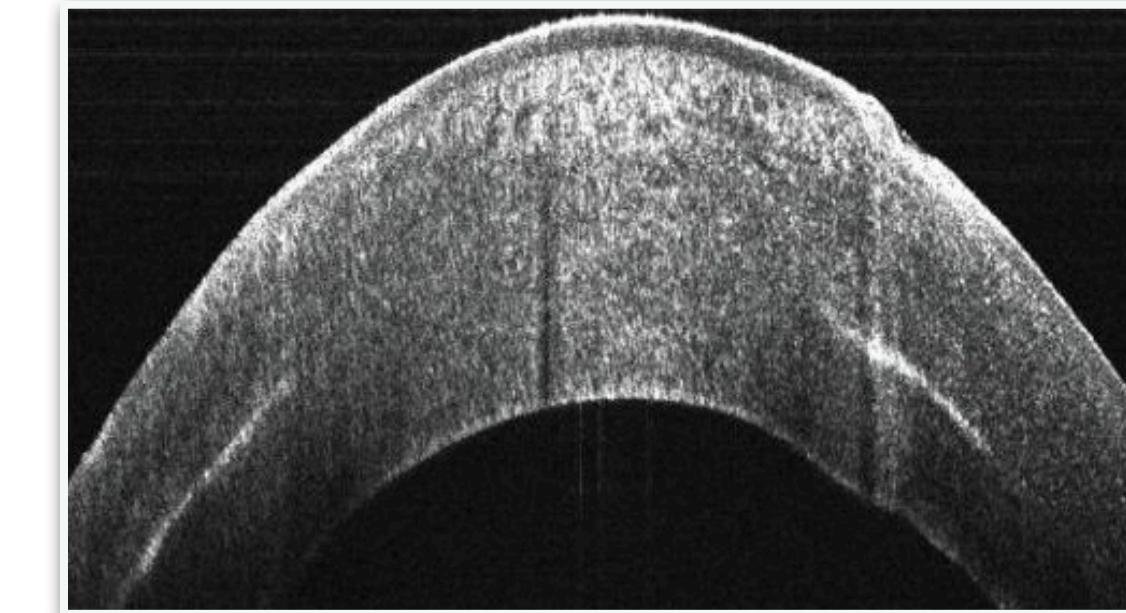
2. Purpose

3. Method

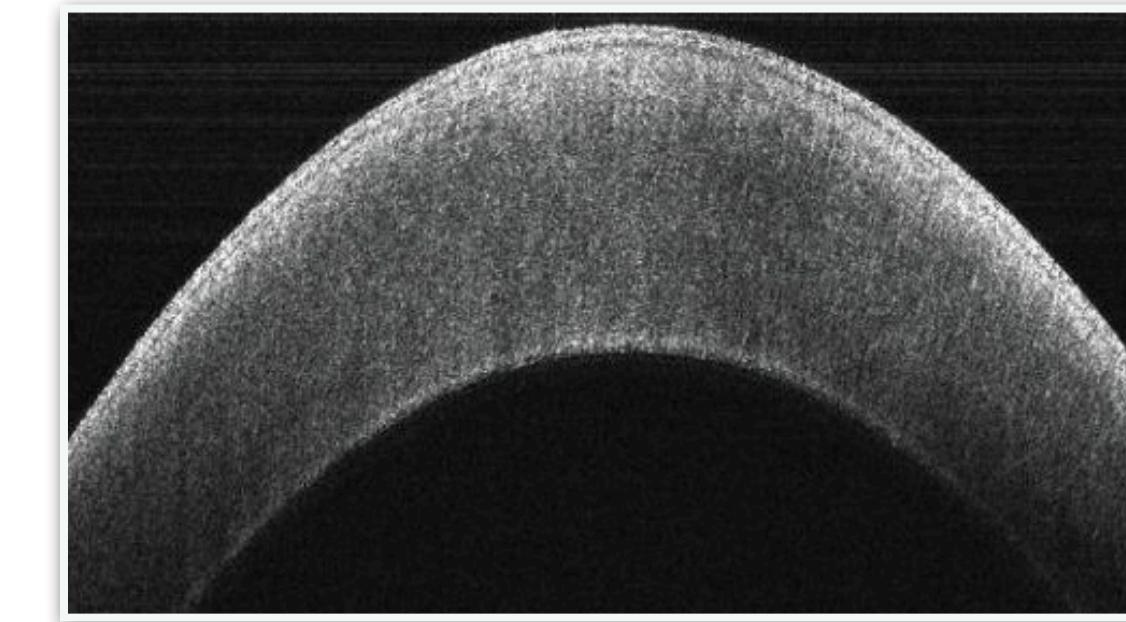
Groups



ICRS implantation



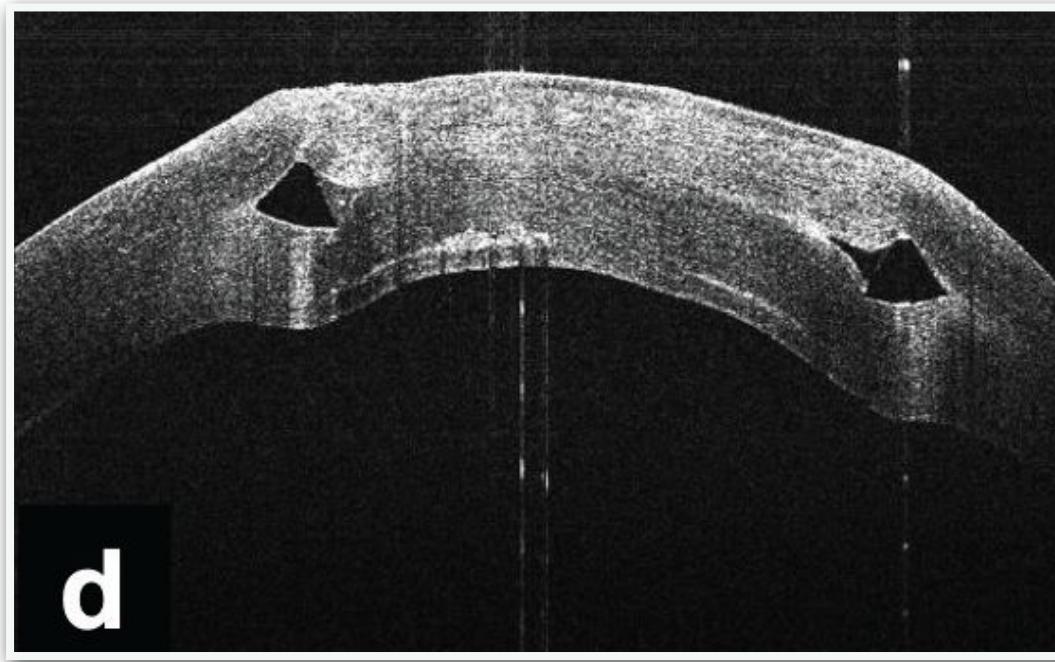
Tunnel creation



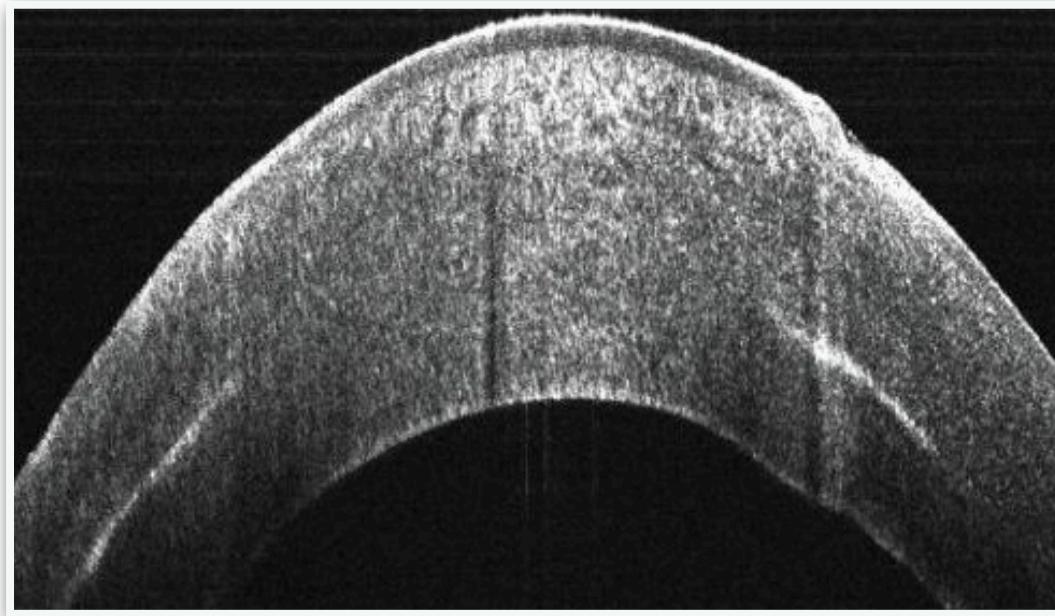
Virgin control



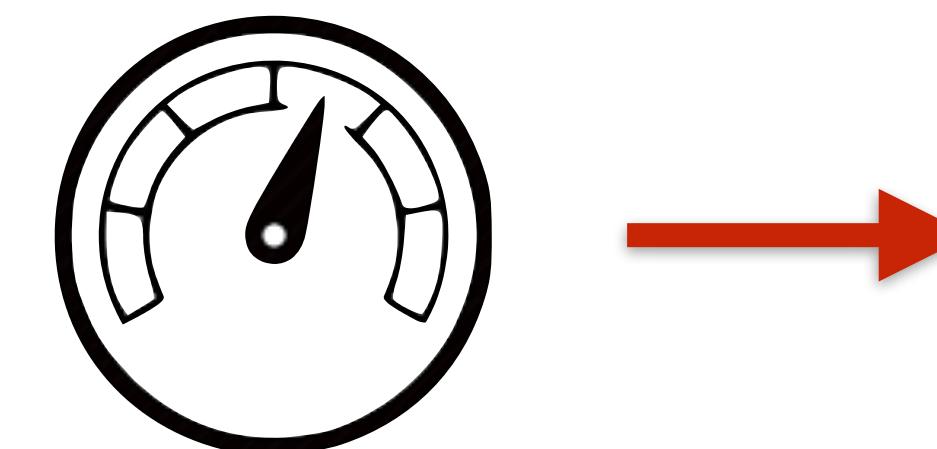
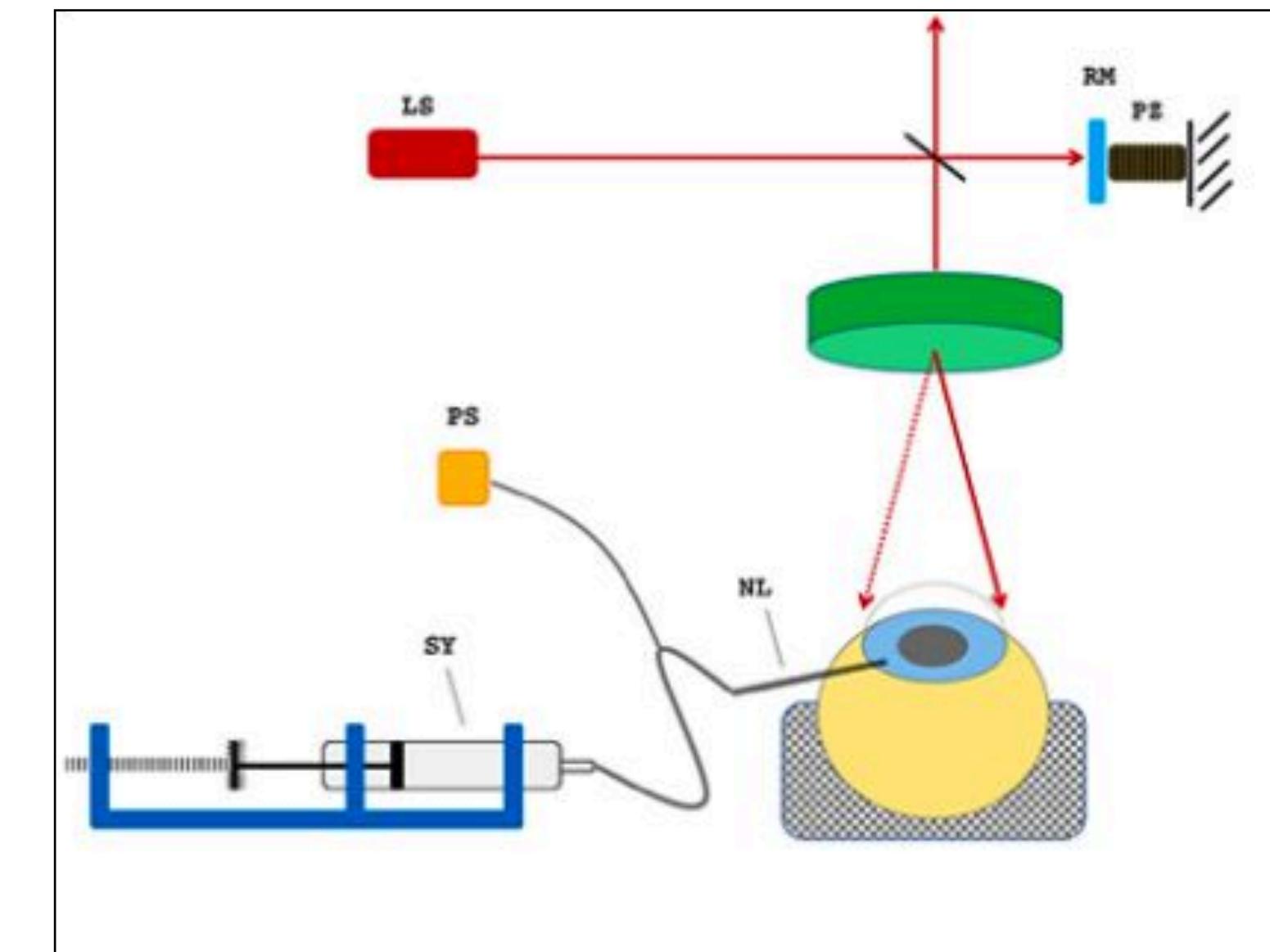
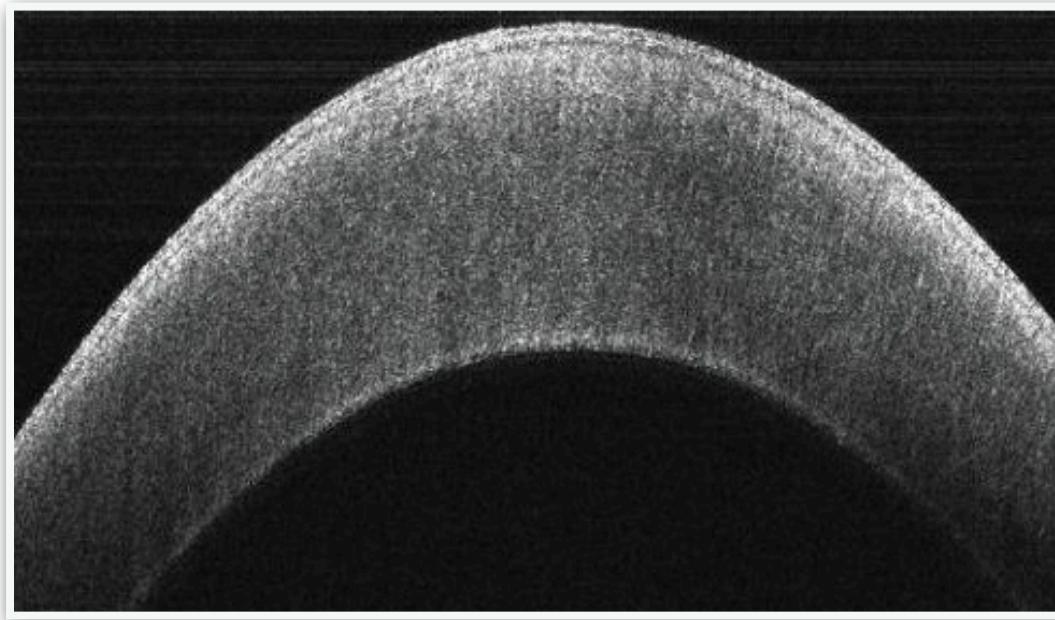
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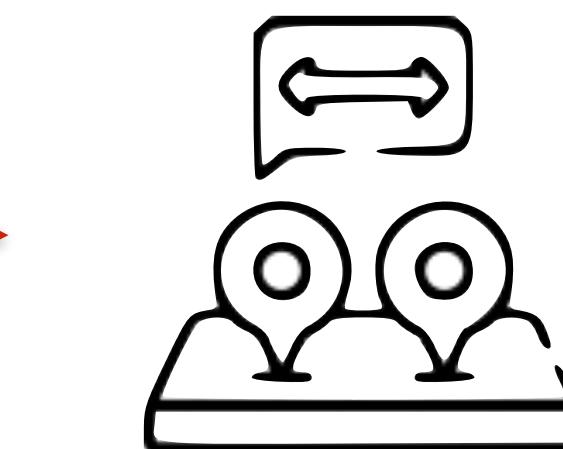
2. Purpose



3. Method



IOP variation



OCT Displacement



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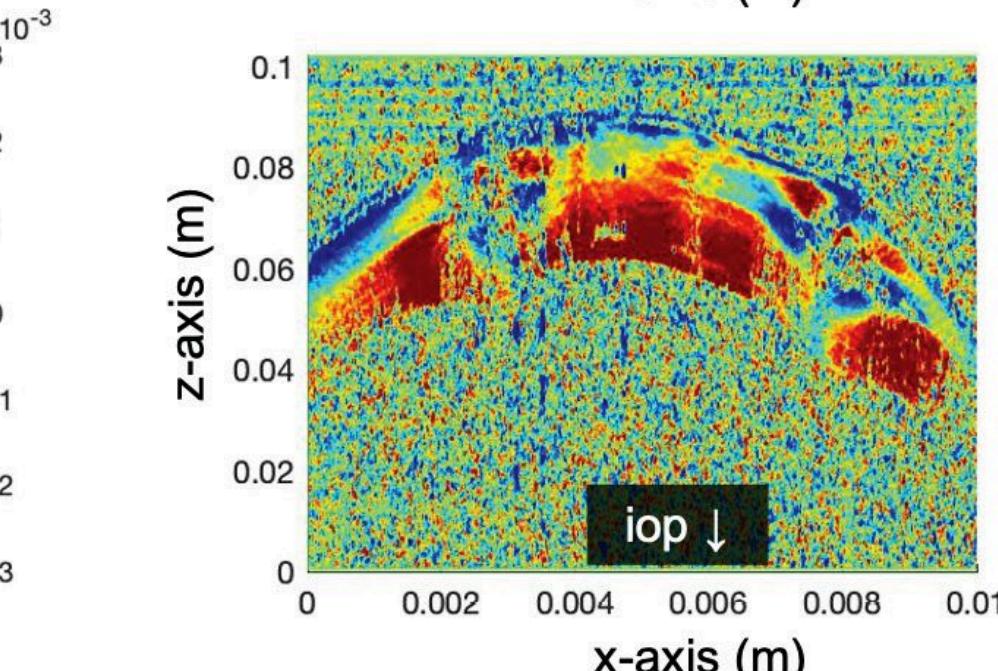
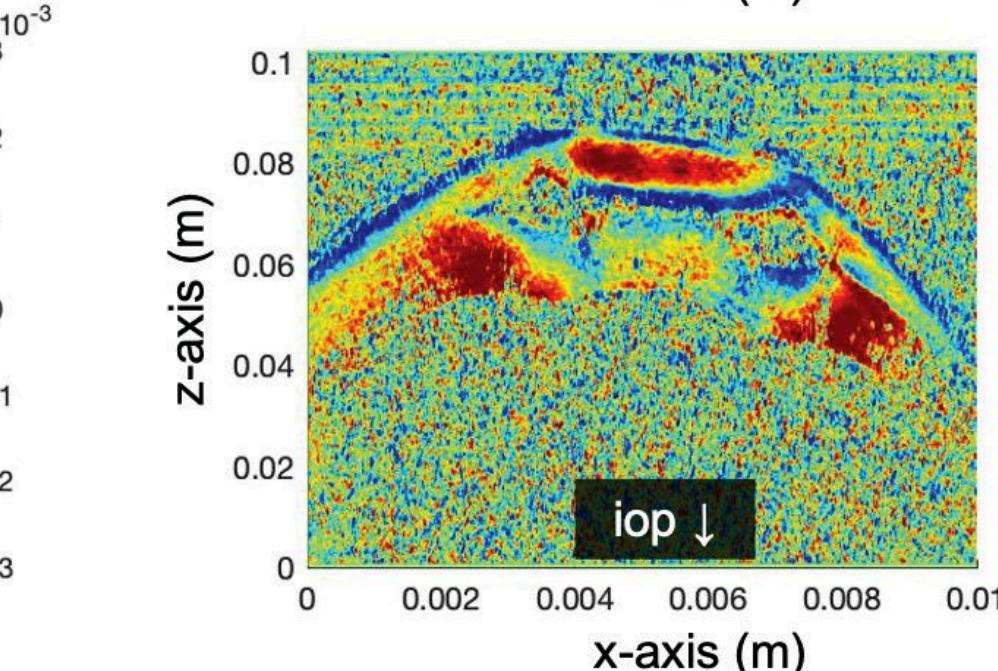
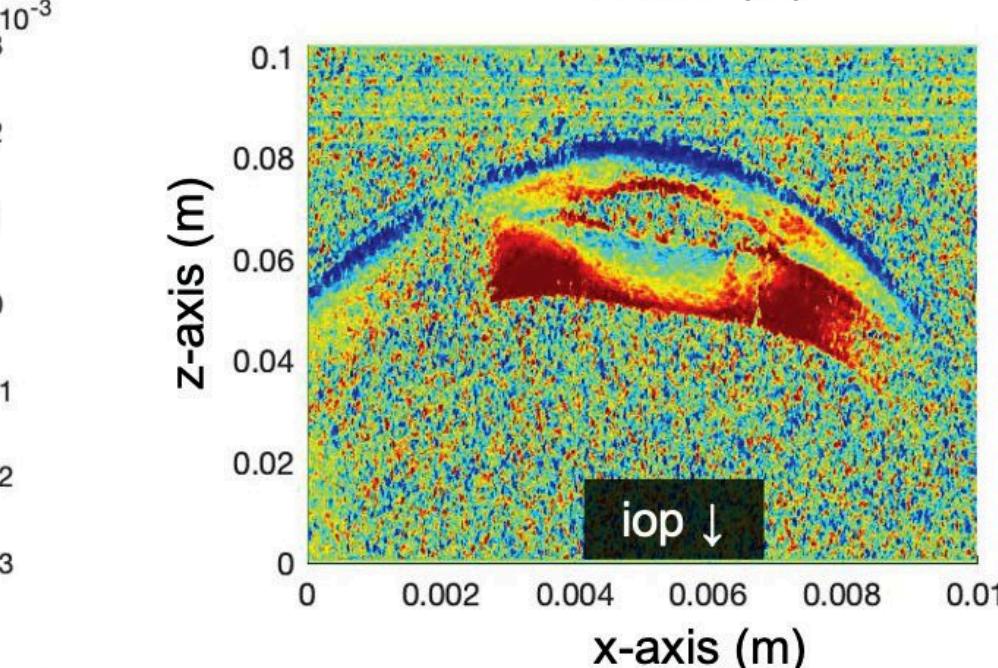
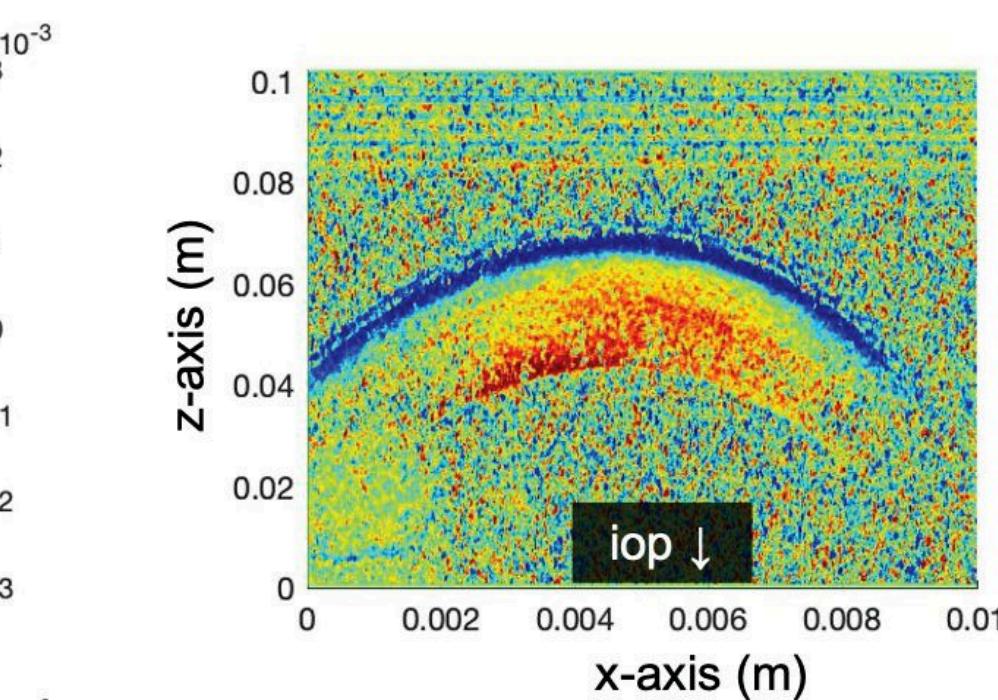
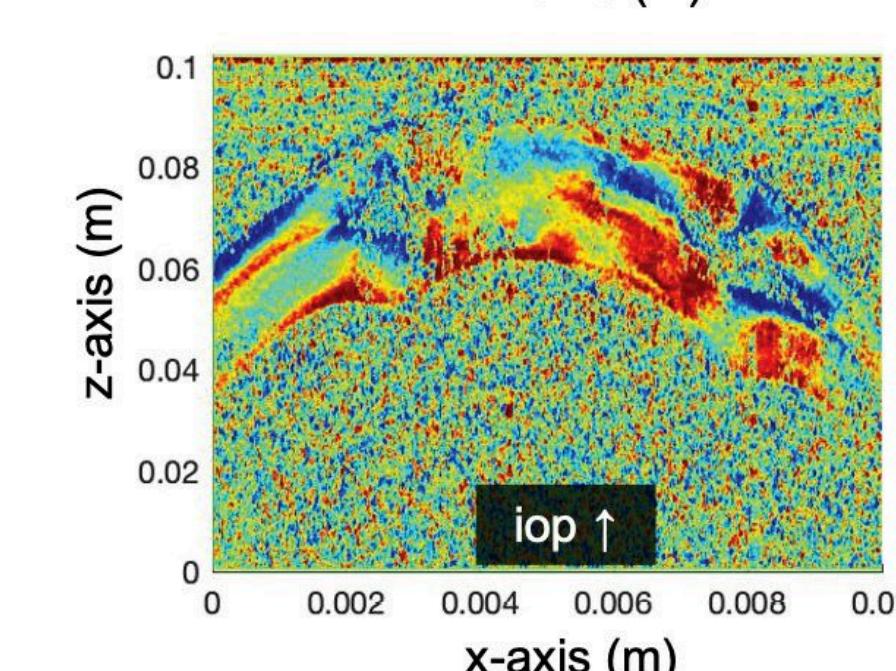
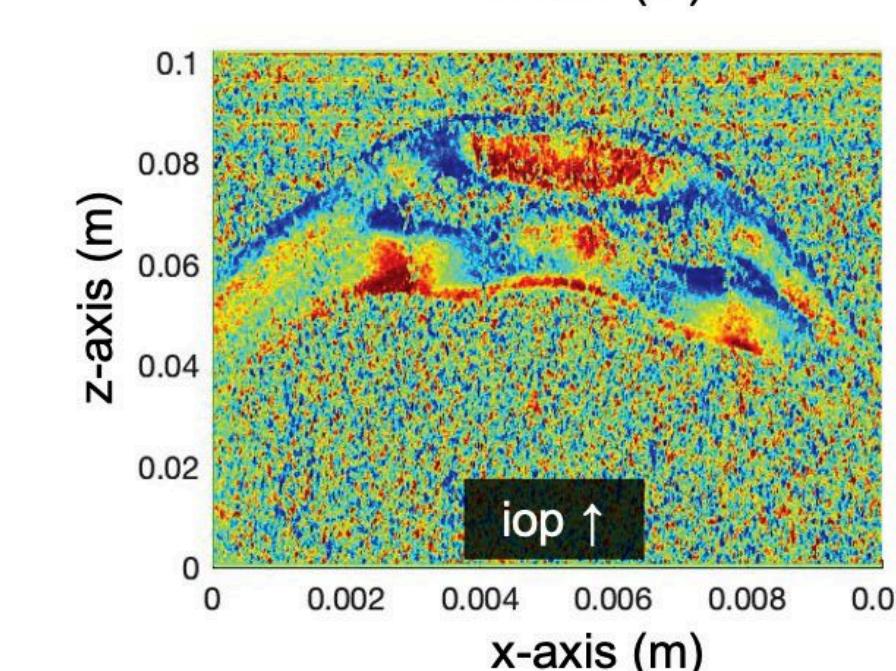
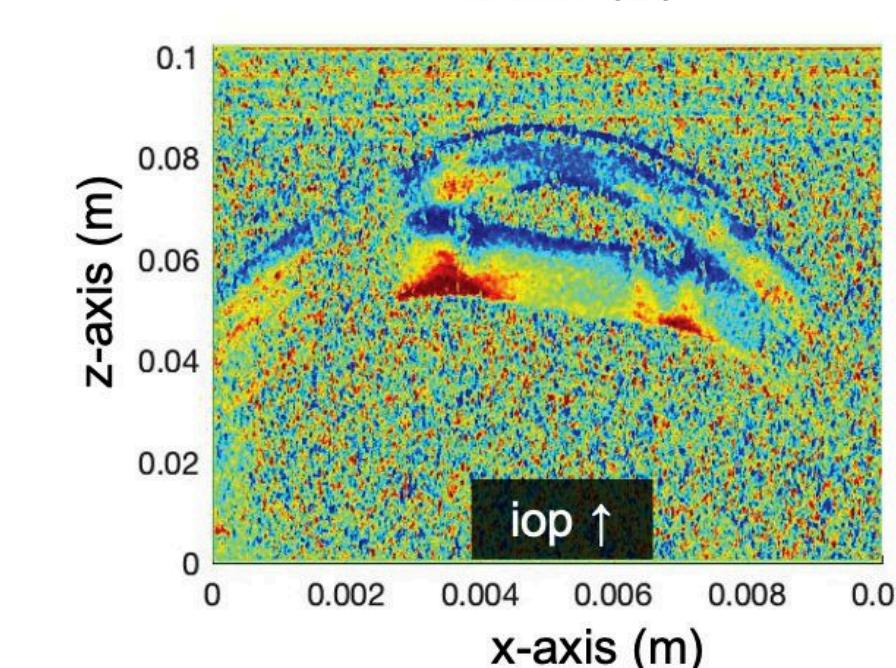
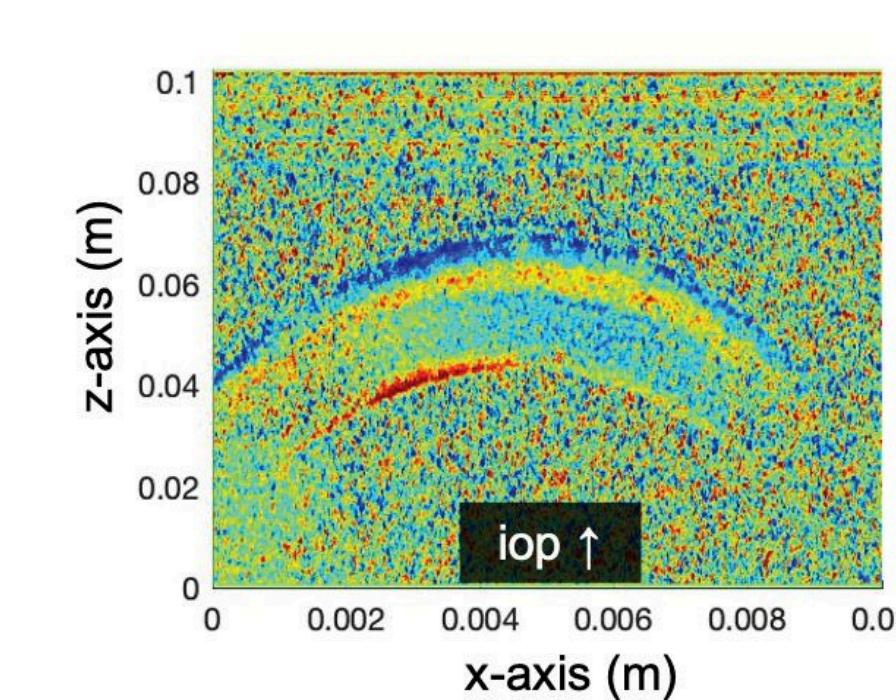
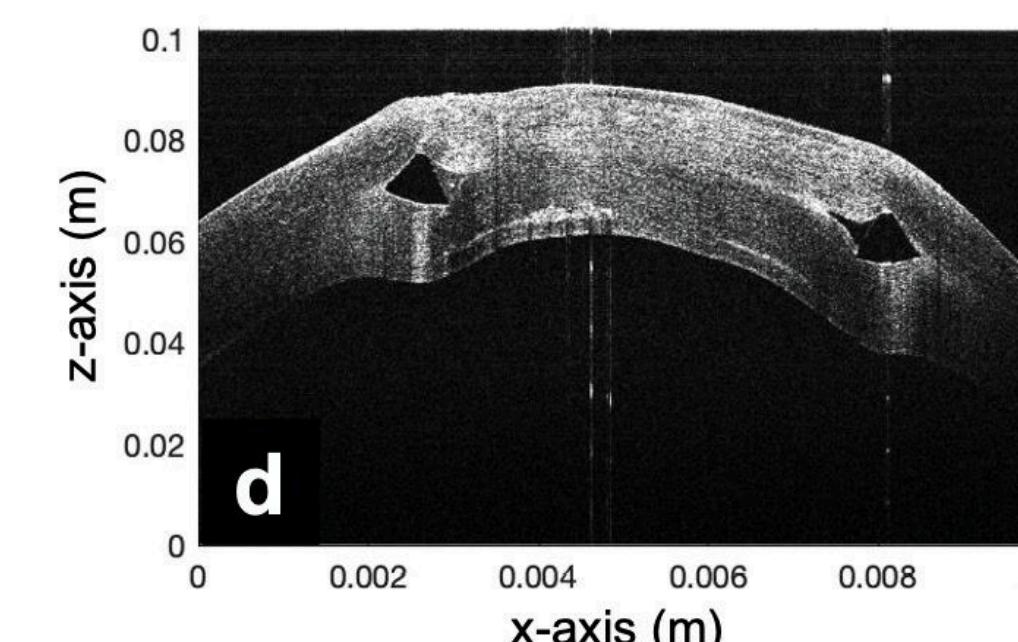
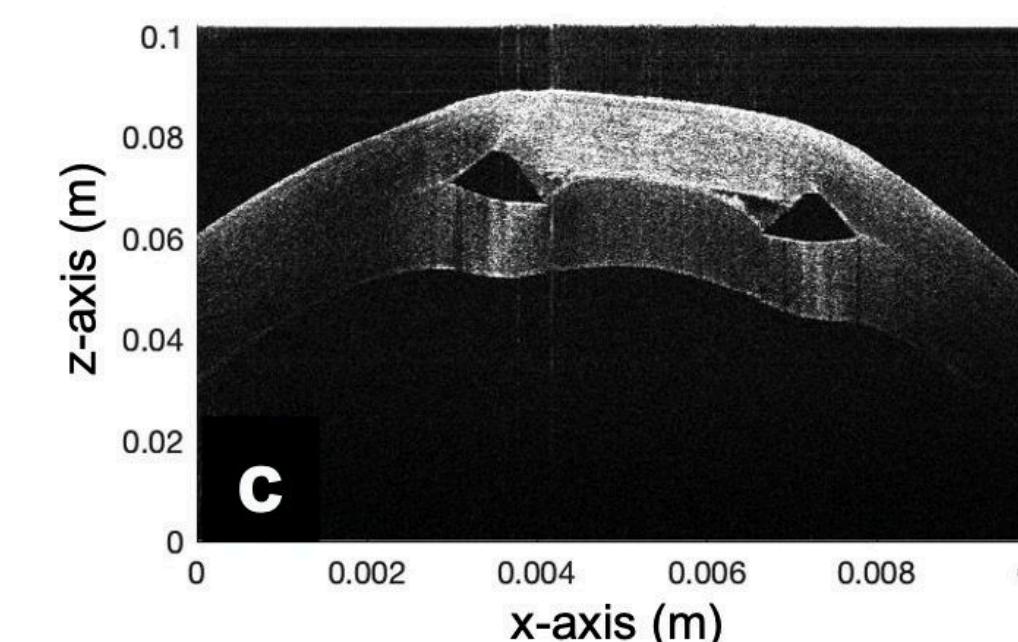
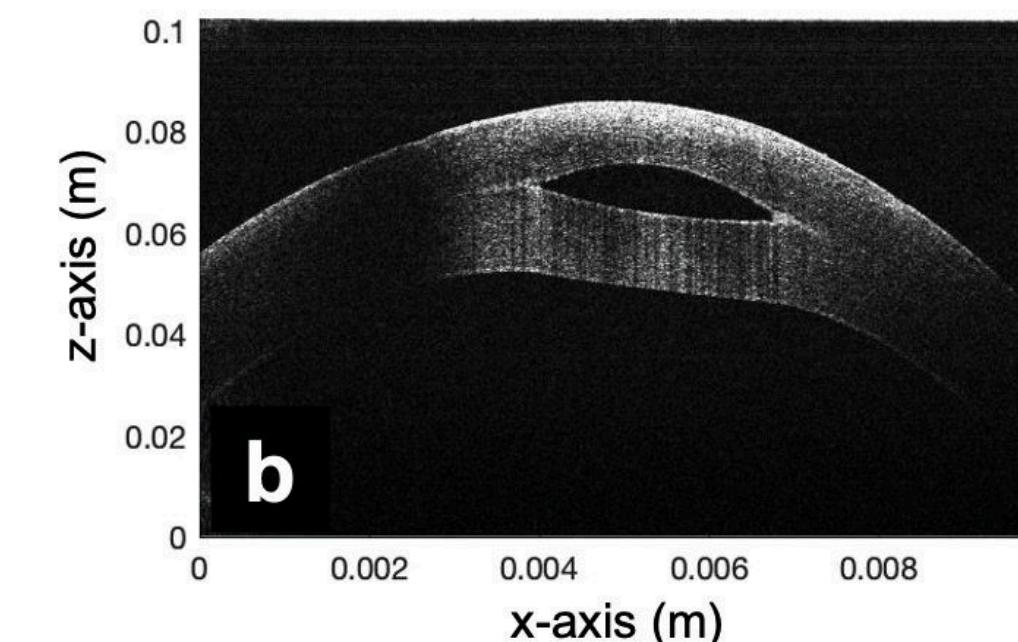
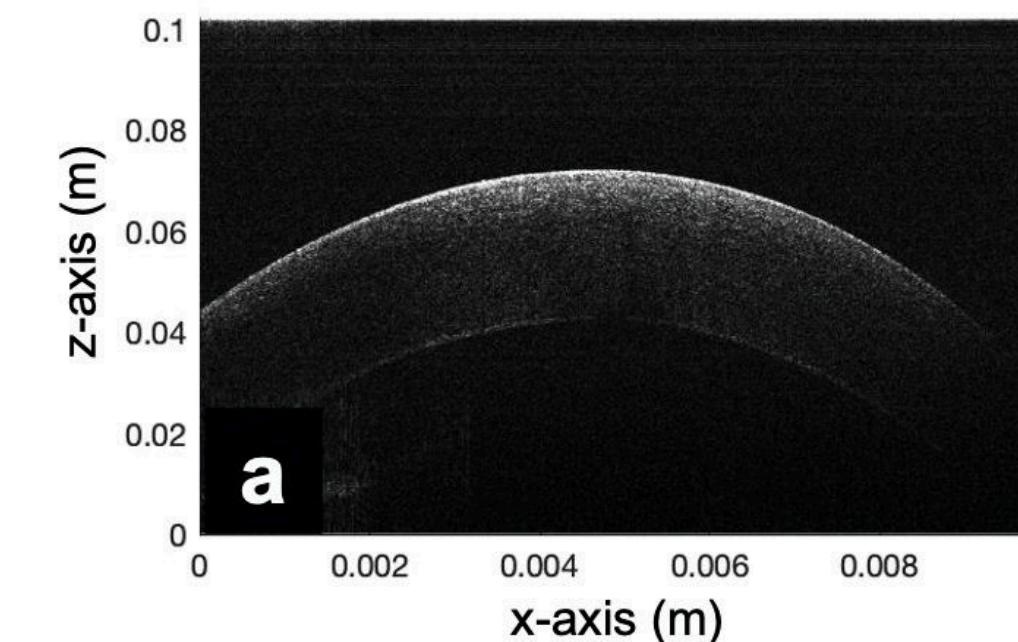
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1. Background

2. Purpose

3. Method

4. Results



Torres-Netto et al, JRS 2022
in press



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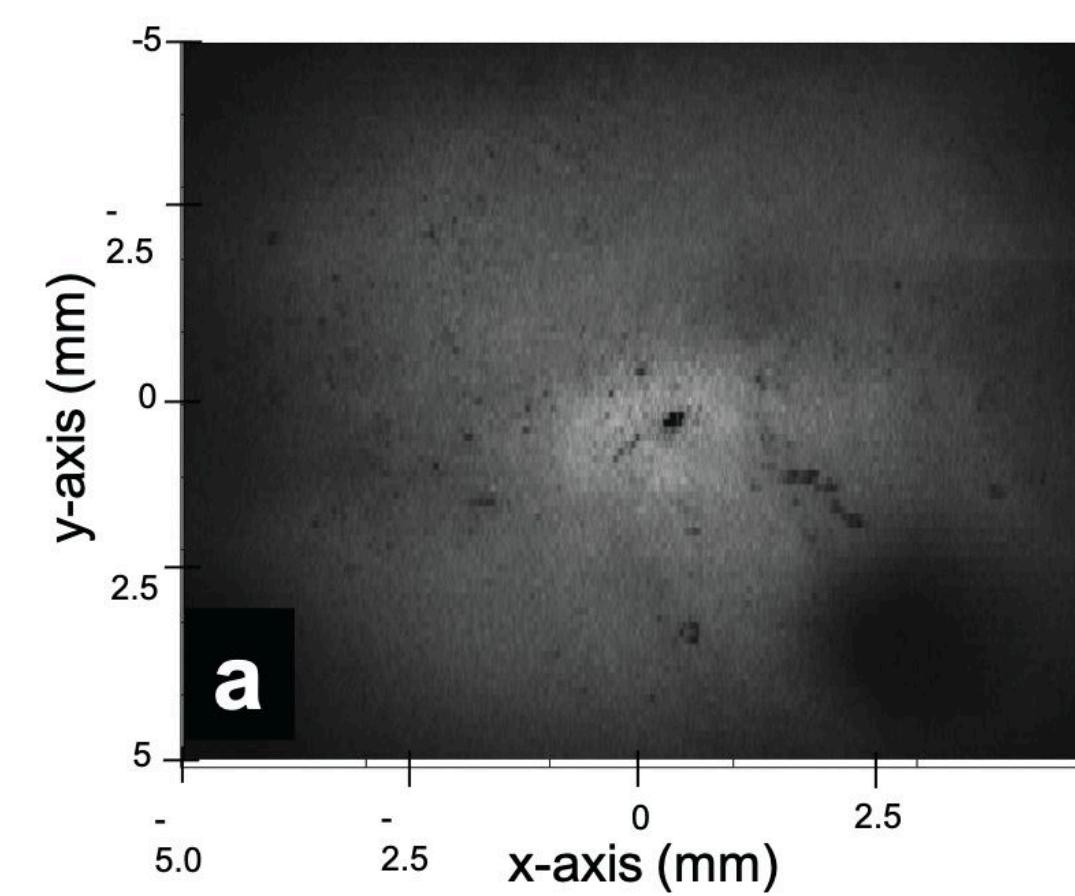


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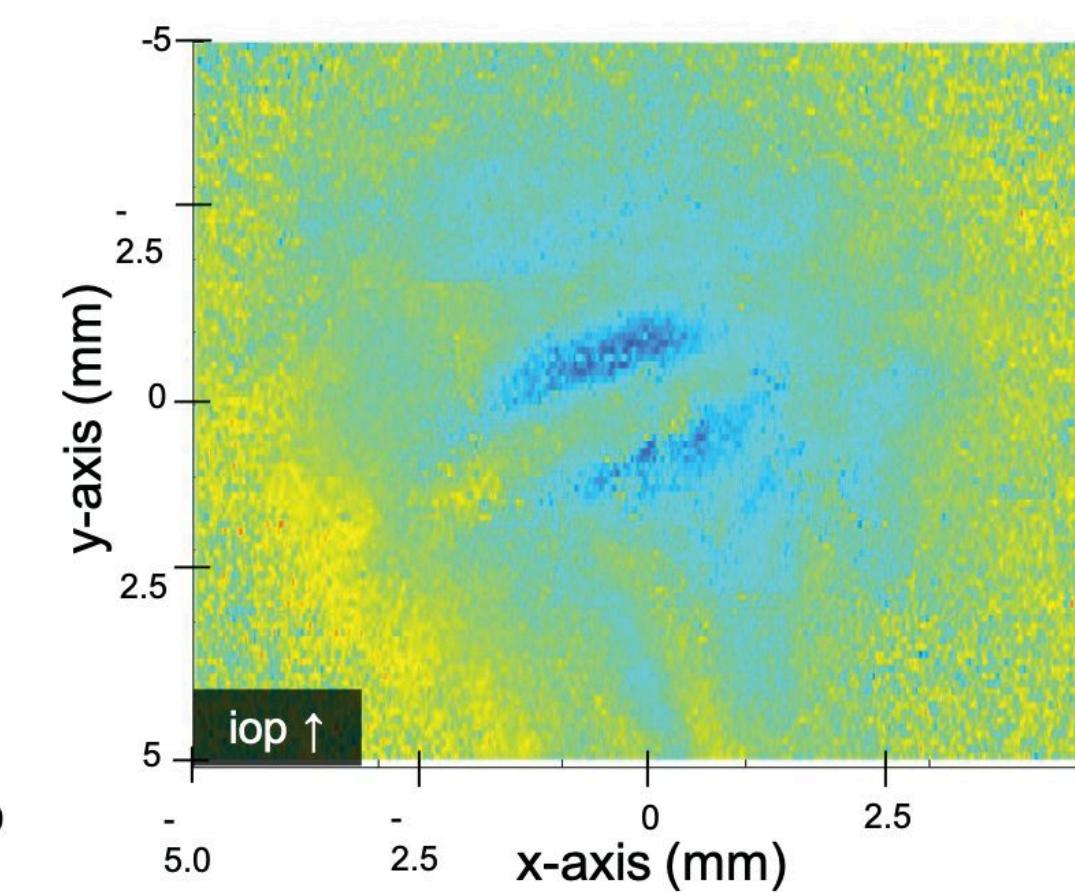


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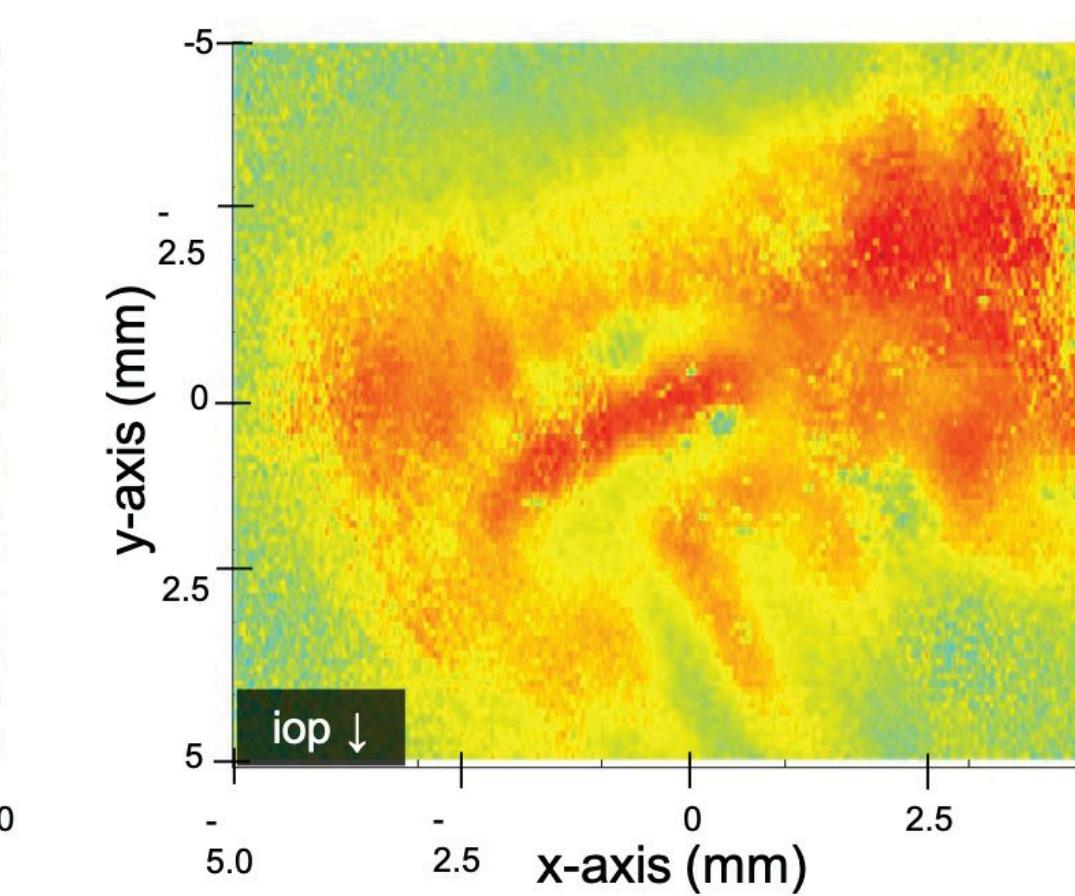
1. Background



a

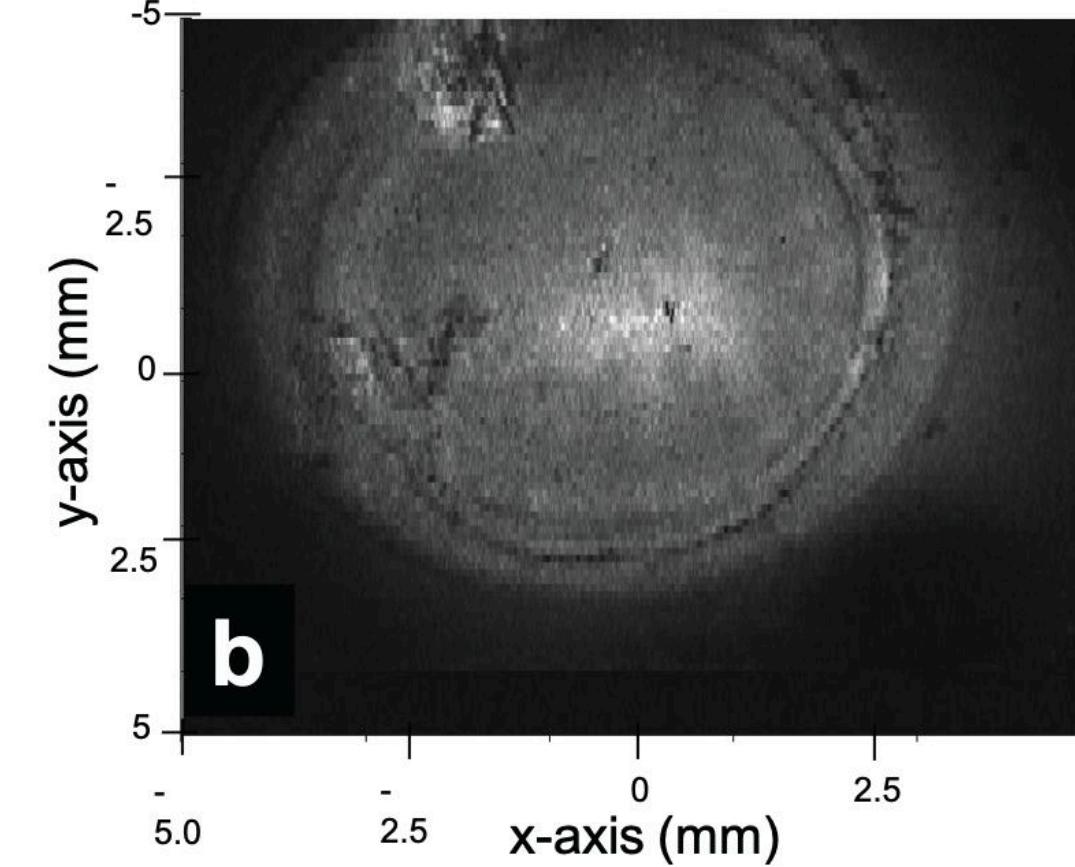


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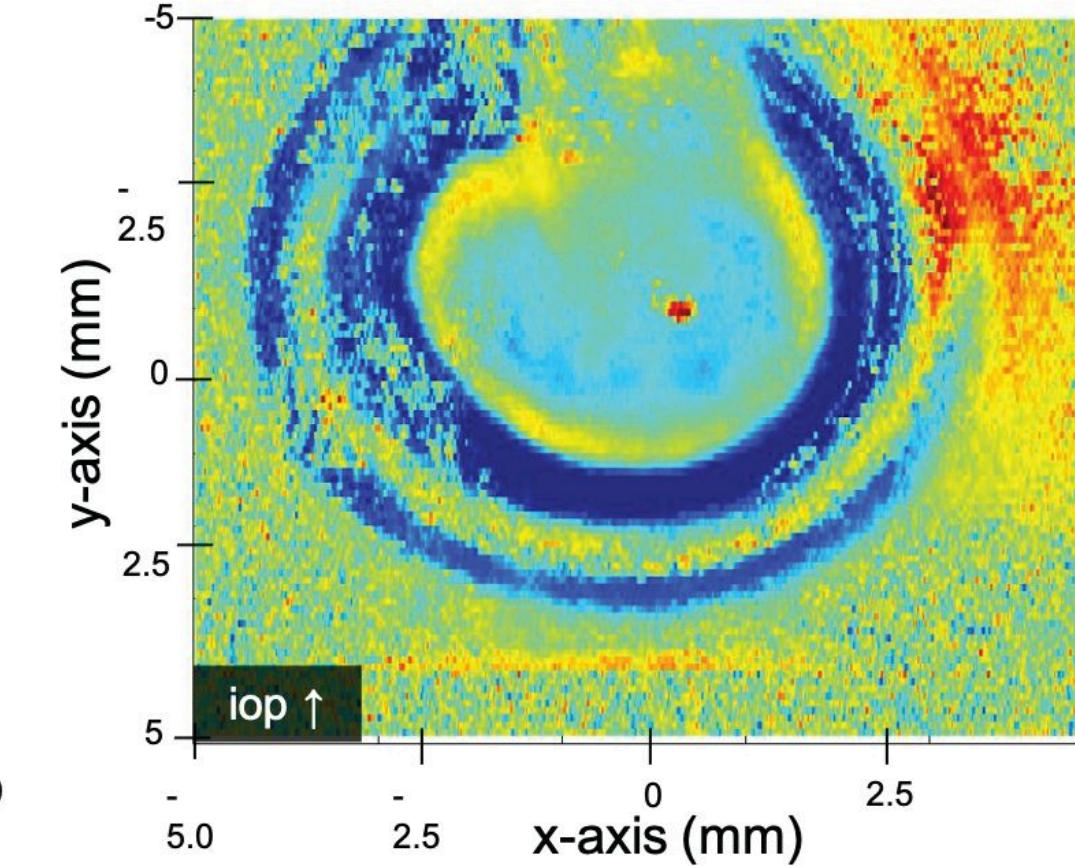


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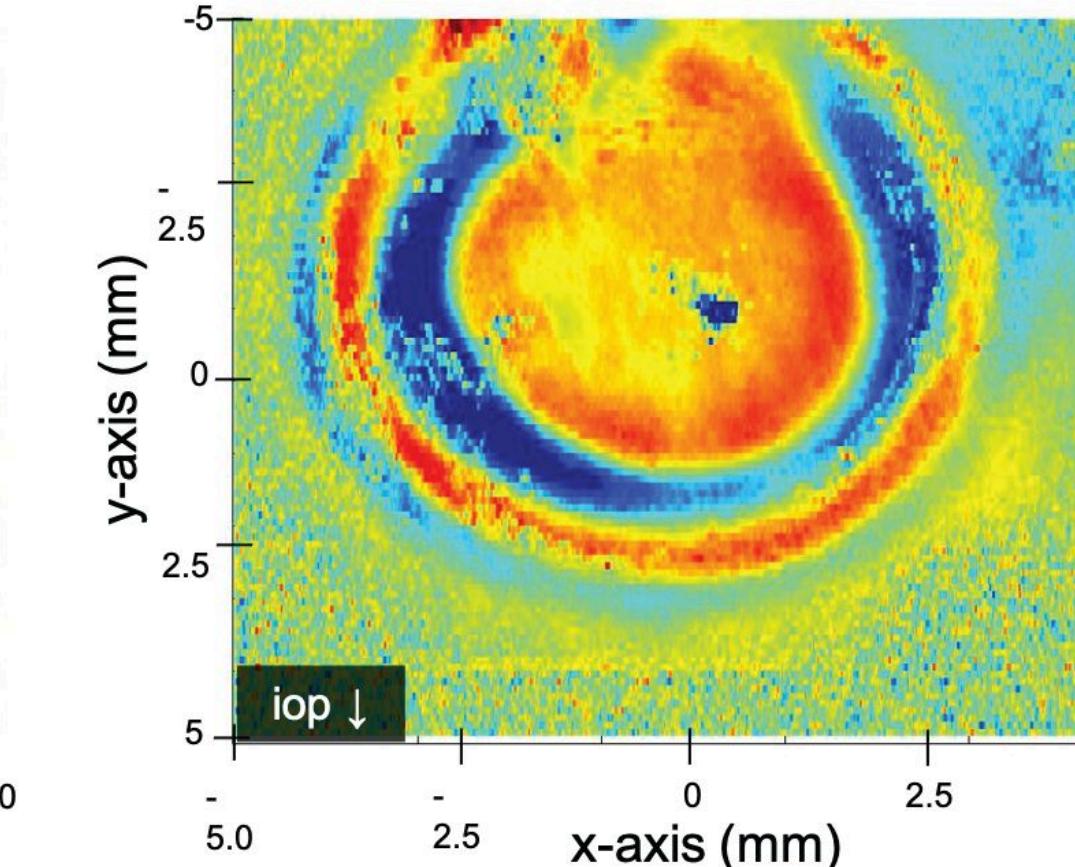
2. Purpose



b

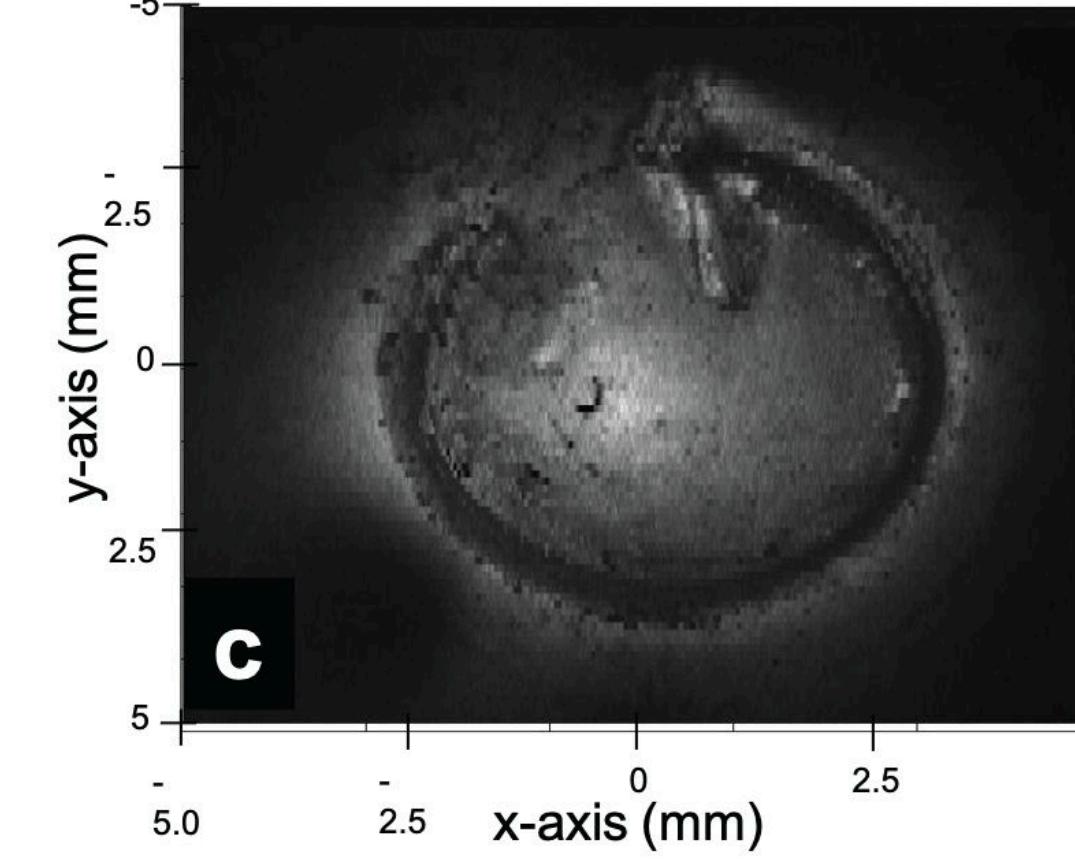


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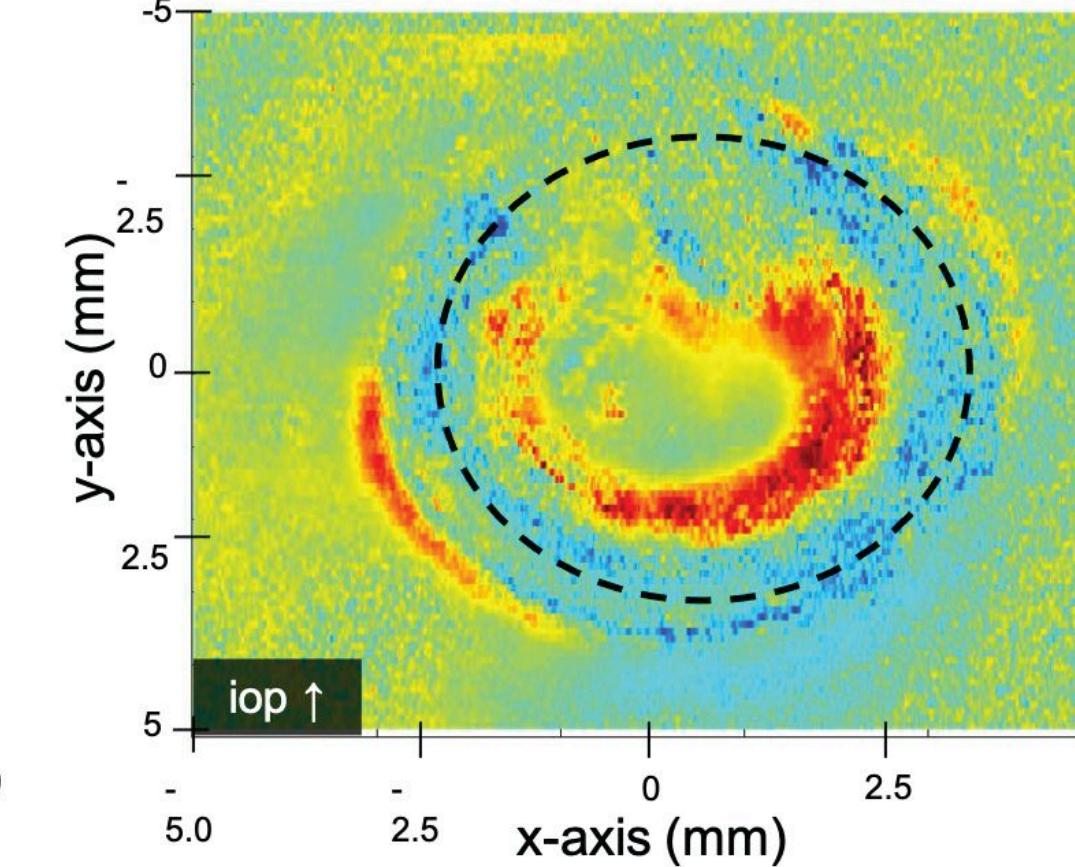


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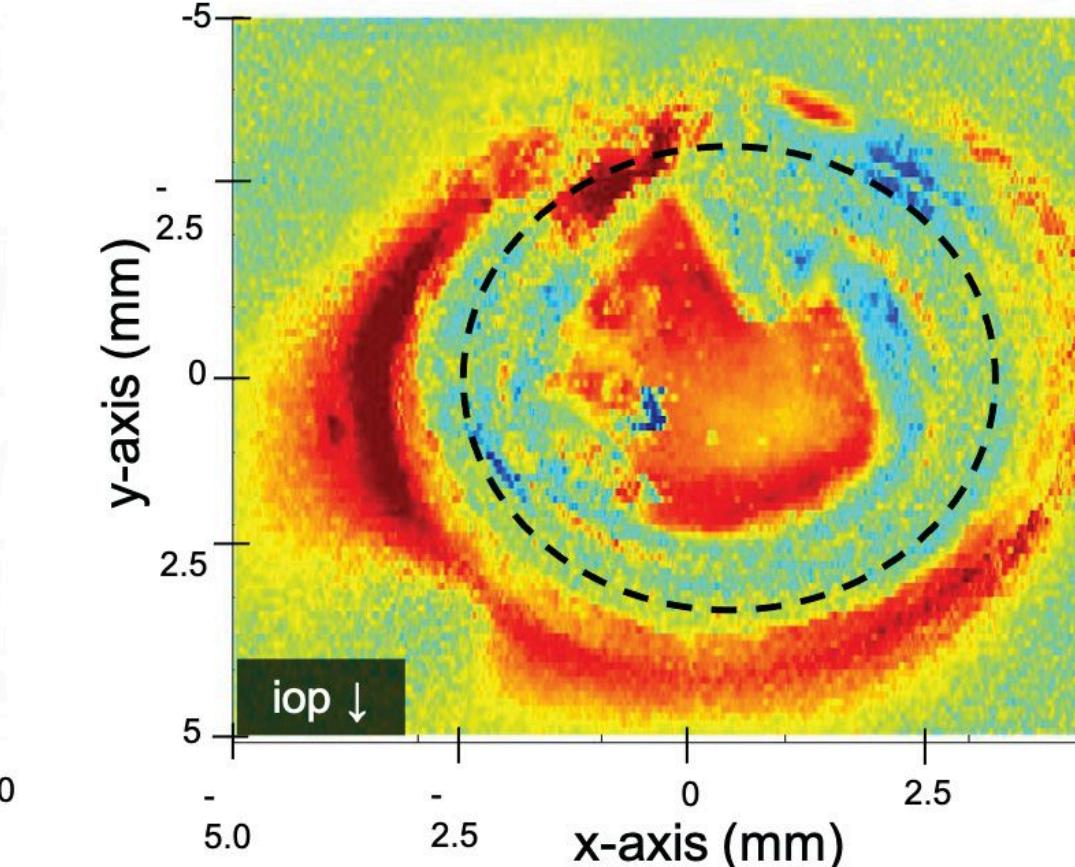
3. Method



c



iop ↑



iop ↓



1. Background

2. Purpose

3. Method

4. Results

5. Summary

Summary

- 1** For the **first time** it was possible to obtain **strain maps** of the corneas **after ICRS implantation using OCT-Elastography**;
- 2** ICRS implantation induces localized **strains in the regions subjected to refractive changes**;
- 3** This suggests that corneal **strain** and **curvature** are **directly related**;
- 4** Studying corneal strain in response to surgical intervention may provide **new insights on underlying working principles**;
- 5** OCT-Elastography opens new horizons for its use in monitoring the **progression of corneal ectasia** and to determine the **success of corneal cross-linking**.

THANK YOU

