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**Detecting deformation asymmetries on multiple meridians in an *ex vivo* keratoconic eye model**

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* Footnotes

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Abstract

**Purpose**: Ocular biomechanical simulations show that air-puff induced corneal deformation imaging (APCDI) can reveal pathological asymmetric responses, as in eccentric keratoconus. Such asymmetries often go undetected when monitoring deformation on only one meridian (Birkenfeld *et al.*, IOVS, 2019), as is the case with commercial instruments. We present a novel custom optical coherence tomography (OCT) system coupled with an air-puff module capable of detecting deformation asymmetries on multiple meridians in a keratoconic-mimicking *ex vivo* porcine eye model.

**Methods**: Corneal deformation was induced by a piston-based air-puff module colinearly coupled to a custom OCT system. The puff module provided an air-puff FWHM duration of ~11 ms, reaching a maximum pressure on the corneal apex of ~13 kPa. Our OCT system used a 200 kHz 1300 nm VCSEL swept source, with an axial range of 26 mm.
A freshly enucleated porcine eye globe was treated with a cross-linking (CXL) protocol with Rose Bengal (RB) photosensitizer and Green light irradiation (0.25 W/cm2, 2x200 s) of only the lower half of the cornea. We performed OCT APCDI measurements under controlled intraocular pressure (IOP, 15-30 mmHg) after application of RB (=baseline, BSL) and after partial CXL.
We quantified the displaced area (DA) between the undeformed and deformed anterior cornea positions and asymmetry in displaced area (ADA),*i.e.* the difference between the nasal/temporal (or superior/inferior) DA referenced to the undeformed corneal apex.

**Results**: We implemented a cross-meridian scan pattern over a lateral range of 15 mm sampled with 64 points at a repetition frequency of 1 kHz.
For the BSL case, we validated the system by verifying the reduction of DA, from a maximum of ~4.3 to 1.8 mm2, with increasing IOP, from 15 to 30 mmHg. ADA was limited to below 0.2 mm2in all cases for both meridians.
For the partial CXL case and an IOP of 15 mm Hg, the ADA peaked at 0.5 mm2for the vertical meridian, while it was below 0.2 mm2at all times for the horizontal meridian.

**Conclusions**: We acquired corneal deformation images with a cross-meridian scan pattern over a field of view of 15 mm at unprecedented scan rates. In keratoconus-mimicking cases, we detected deformation asymmetries up to 0.5 mm2, otherwise missed on a single meridian, that will substantially aid in corneal biomechanics diagnostics and pathology screening.

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