XV JORNADA DE JÓVENES INVESTIGADORES/AS DEL I3A

Toward Patient-Specific Mapping of Early Corneal Alterations

Juan Casado-Moreno and Alejandra Consejo

Tecnologías Ópticas Láser (TOL), Instituto de Investigación en Ingeniería de Aragón (I3A)

jcasado.moreno@unizar.es

A method for cone demarcation in keratoconus

- **Keratoconus (KC)** is a progressive disease that causes a localized, cone-like deformation of the cornea whose precise demarcation is still not available in clinical practice.
- **Early and patient-specific** identification of the cone is essential to improve diagnosis and support more targeted treatment strategies.
- We propose a method for **cone demarcation** based on **tissue-derived features** extracted from Scheimpflug images. **The aim** is twofold: **(1)** to detect localized changes before clinically evident shape alterations, and **(2)** to support KC staging assessment.

METHODOLOGY

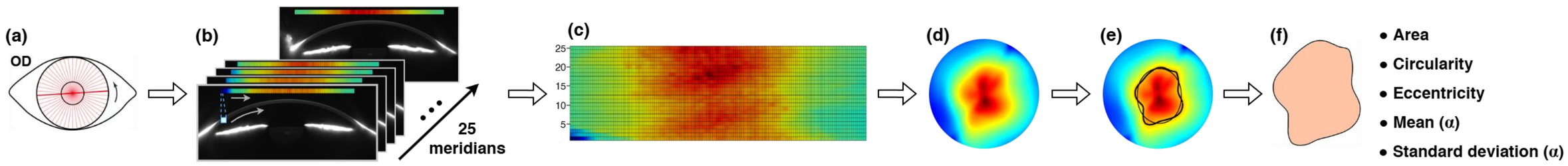

Figure 1: Main steps to obtain corneal tissue maps from each Scheimpflug measurement, followed by cone demarcation and feature extraction.

A total of 92 **control**, 24 subclinical keratoconus (**SKC**), and 104 clinical KC eyes were measured with a corneal Scheimpflug tomographer (Pentacam HR). Clinical KC eyes were further stratified into stages: mild (**MKC**, n = 54), and advanced (**AKC**, n = 50). Pachymetry maps were exported from the Pentacam HR, while tissue-derived maps were generated from Scheimpflug images [1] (Figure 1). Briefly, the 25 meridians captured per eye (Figure 1a) were segmented and analyzed using a moving ROI (Figure 1b) to extract pixel intensity distributions, fitted with a Weibull function to obtain spatially resolved tissue parameters (shape and scale) [2]. The **scale parameter (α)** was used to reconstruct 2D tissue maps (Figure 1c–d). Cone demarcation was then performed using a fixed threshold and Fourier-based contour representation (Figure 1e), from which five contour-derived parameters were extracted (Figure 1f).

RESULTS

1. Cone demarcation for subclinical detection

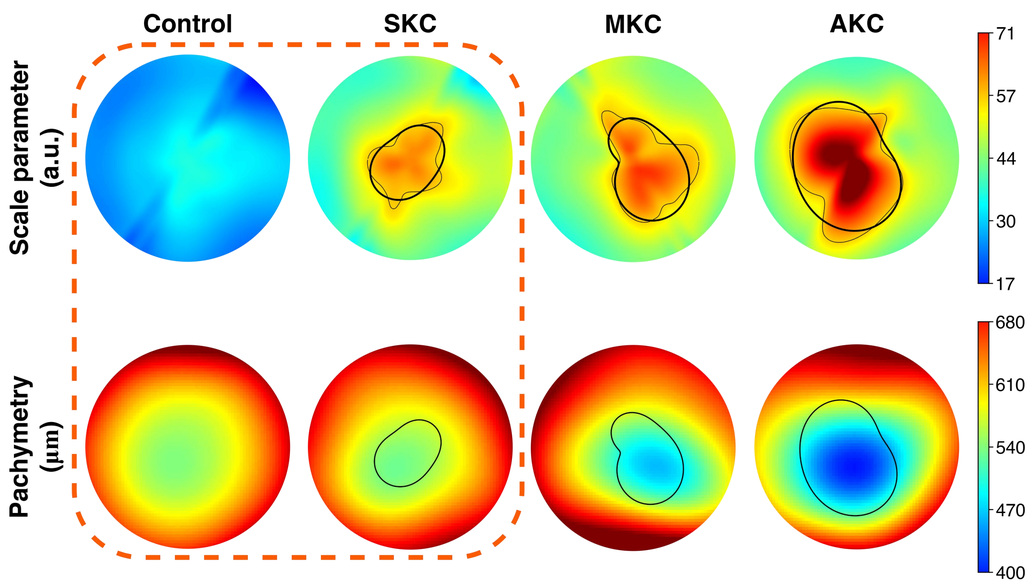

Figure 2: Representative tissue-derived and tomographic maps with projected cone demarcation across study groups.

2. Cone demarcation for KC staging

Table 1: Pairwise comparisons between keratoconus stages. Statistical significance is indicated as follows: ✓ (p < 0.05), ✓✓ (p < 0.01), ✓✓✓ (p < 0.001), and ✗ (p ≥ 0.05). SKC < MKC < AKC

	SKC vs MKC	SKC vs AKC	MKC vs AKC
Area	✗	✓✓	✗
Circularity	✗	✓	✗
Eccentricity	✓✓	✓✓✓	✗
Mean (α)	✓✓	✓✓✓	✓✓
Standard deviation (α)	✓	✓✓✓	✓✓

α: scale parameter of the Weibull distribution

- Cone size increases with keratoconus severity.
- Tissue-derived cone alterations precede detectable tomographic shape changes.
- Cone mean and standard deviation of α are the most informative metrics for keratoconus staging.

[1] CONSEJO, A., JIMÉNEZ-GARCÍA, M., ISSARTI, I., and ROZEMA, J.J. Detection of subclinical keratoconus with a validated alternative method to corneal densitometry. Translational Vision Science & Technology. 2021, 10(9), 32.

[2] CASADO MORENO, J., ARIZCUREN, A., ROZEMA, J.J., and CONSEJO, A. Combination of tissue-derived and shape-based parameters for subclinical keratoconus detection. Biomedical Optics Express. 2026, 17(6), 3100-3116.

Take home message

Tissue-derived cone mapping enables subclinical detection and disease staging.

Supported by European Research Council under the European Union's Horizon Europe research and innovation programme, StG 2024 call (VISIONSAFE), 101162733