Universal architecture of corneal segmental tomography biomarkers for artificial intelligence-driven diagnosis of early keratoconus

Abstract

Aims To develop a comprehensive three-dimensional analyses of segmental tomography (placido and optical coherence tomography) using artificial intelligence (AI).

Methods Preoperative imaging data (MS-39, CSO, Italy) of refractive surgery patients with stable outcomes and diagnosed with asymmetric or bilateral keratoconus (KC) were used. The curvature, wavefront aberrations and thickness distributions were analysed with Zernike polynomials (ZP) and a random forest (RF) AI model. For training and cross-validation, there were groups of healthy (n=527), very asymmetric ectasia (VAE; n=144) and KC (n=454). The VAE eyes were the fellow eyes of KC patients but no further manual segregation of these eyes into subclinical or forme-fruste was performed.

Results

The AI achieved an excellent area under the curve (0.994), accuracy (95.6%), recall (98.5%) and precision (92.7%) for the healthy eyes. For the KC eyes, the same were 0.997, 99.1%, 98.7% and 99.1%, respectively. For the VAE eyes, the same were 0.976, 95.5%, 71.5% and 91.2%, respectively. Interestingly, the AI reclassified 36 (subclinical) of the VAE eyes as healthy though these eyes were distinct from healthy eyes. Most of the remaining VAE (n=104; forme fruste) eyes retained their classification, and were distinct from both KC and healthy eyes. Further, the posterior surface features were not among the highest ranked variables by the AI model.

Conclusions

A universal architecture of combining segmental tomography with ZP and AI was developed. It achieved an excellent classification of healthy and KC eyes. The AI efficiently classified the VAE eyes as ‘subclinical’ and ‘forme-fruste’.

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