AI provides deeper understanding of Meibomian gland morphology and function

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Purpose: To use artificial intelligence to identify relationships between morphological features of the Meibomian glands (MG), subject characteristics, clinical outcomes, and subjective symptoms in contact lens wearers and non-wearers.

Methods: A total of 689 infrared meibography images were collected from 363 subjects (170 contact lens wearers, 193 non-wearers). A deep learning model was trained to take the de-identified meibography images as input, learn a set of detailed morphological features of the MG, and then to predict subject demographics, clinical outcomes related to MG function, tear film stability and ocular surface health, and subjective outcomes related to discomfort and dryness. The deep learning model was further analyzed to identify the most highly weighted features used by the algorithm in the predictions.

Results: Subject age and ethnicity (Asian v. Non-Asian) were predicted with average accuracies of 75.6% and 85.8%, respectively. MG morphological features were heavily weighted predictors for eyelid notching and vascularization, MG expressate quality, extent of corneal staining, and VAS comfort ratings, with accuracies ranging from 65% to 96%. Lissamine green conjunctival staining was a top predictor for aqueous deficiency diagnosis, greater corneal staining depth, shorter NITBUT, lower VAS average comfort rating, and higher VAS end-of-day severity and frequency of dryness ratings. Among contact lens wearers, alcohol and caffeine consumption were top predictors for symptoms of dry eye while more time outdoors and exercising predicted lower symptom scores. Hours per day of contact lens wear was not a heavily weighted predictor for most symptoms, however more hours per day of comfortable wear was a predictor for lower OSDI and SPEED scores as well as for lower VAS ratings of severity and frequency of discomfort and dryness. Overall, the deep learning models achieved prediction accuracies ranging from 61% to 99%.

Conclusions: The artificial intelligence approach used in this study can predict demographic features from de-identified meibography images (which are not considered Protected Health Information [PHI]) with better than 75% accuracy, which is likely to improve in the future with the advancing capabilities of machine learning models. Machine-derived MG features were found to be important in predicting multiple signs and symptoms, and this automated method shows promise in advancing the study of the role of detailed MG morphology in health and disease.