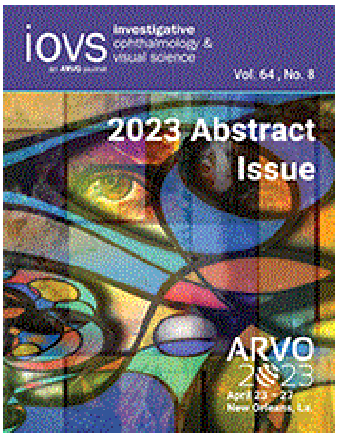

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Convolutional Neural Networks for Keratoconus Detection in Corneal Curvature Maps with and without Compact Convolutional Transformer Architecture

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Footnotes

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Abstract

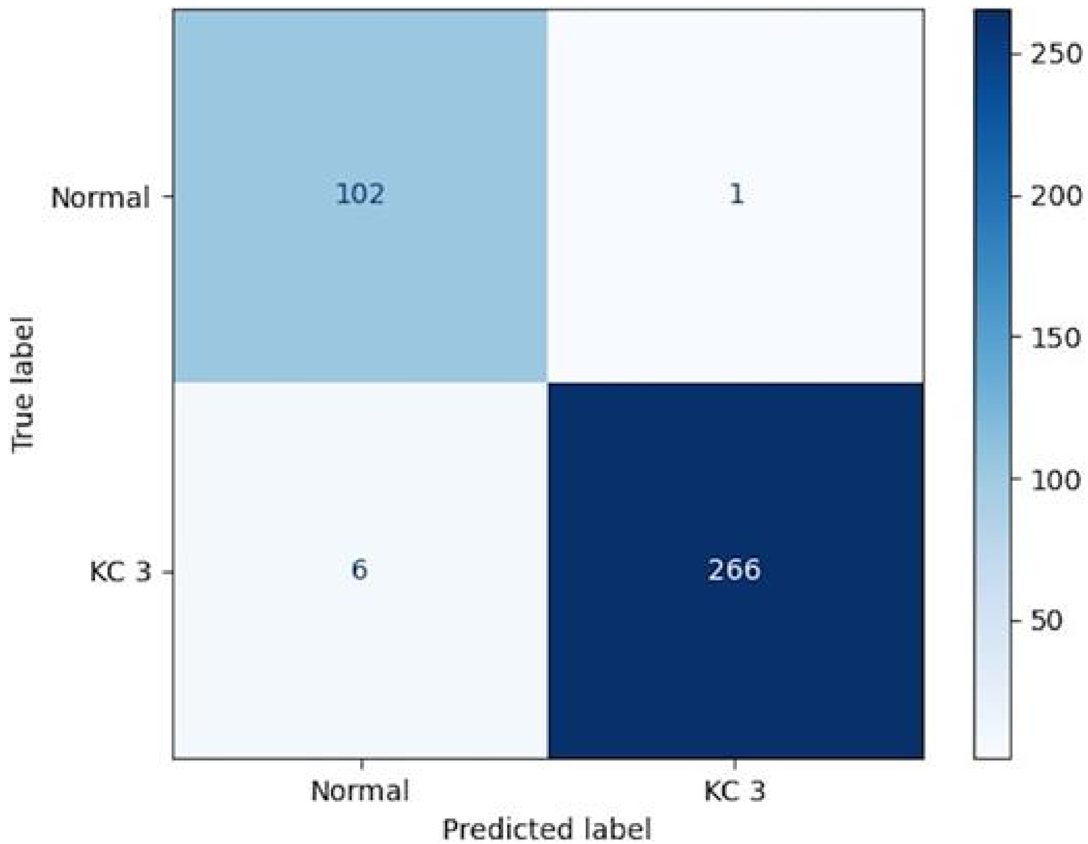
Purpose : Early diagnosis of keratoconus allows timely treatment and visual rehabilitation. It is most commonly achieved by expert analysis of the anterior corneal profile. Artificial intelligence is widely used for image classification and can play an important role as a diagnosis assistant tool. We performed a retrospective observational study to develop different convolutional neural networks (CNN) and test their performances in keratoconus detection using corneal curvature maps.

Methods : Scheimpflug axial anterior curvature color maps from normal and keratoconic corneas were collected from a single center. Abnormal corneas were graded by an expert in four severity levels, ranging from KC1 to KC4. Two CNN models were developed using proprietary (M1) and Compact Convolutional Transformer (M2) architectures. The M1 network was trained using normal and KC3 images, while M2 used all labels (60% of the images were used for training, 20% for validation, and 20% for testing). Network performance was measured by its accuracy, sensitivity, and specificity.

Results : Of 2,695 images, 448 were labeled by the expert as normal, 435 as KC1, 469 as KC2, 1,171 as KC3, 172 as KC4. M1 network was trained using 760 images (211 normal, 549 KC3) and achieved an accuracy of 98.13%, with 97.79% sensitivity and 99.03% specificity (figure 1). M2 was trained using 2,156 images (359 normal, 348 KC1, 375 KC2, 937 KC3, 137 KC4) with accuracy of 78.85% (figure 2). Even though M2 had a lower accuracy, it was capable of adequately stratifying images – only 4 images (0.74%) were classified beyond adjacent severity levels. Thus, the correct diagnosis was contained within one grade of the predicted classification in 99.26% of the tested images.

Conclusions : The developed CNN models were able to detect keratoconus in the tested sample. Furthermore, M2 could correctly classify cornea abnormalities within an acceptable range of one severity level. These models could constitute an important tool for screening at-risk corneas in the general population if similar results are obtained in clinical settings and other populations.

This abstract was presented at the 2023 ARVO Annual Meeting, held in New Orleans, LA, April 23-27, 2023.



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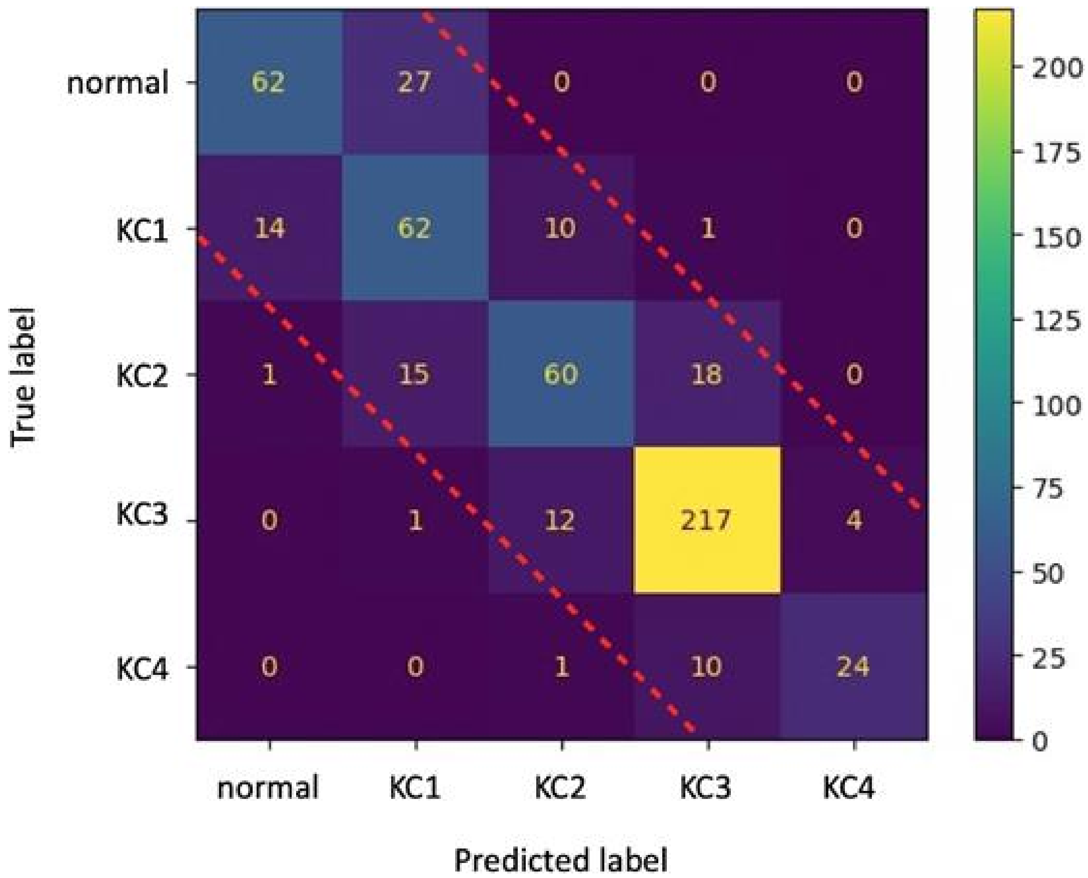
Confusion matrix of M1. Of 375 images, 102 of 103 were correctly labeled as normal and 266 of 272 as KC3.



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Confusion matrix of M2. Of 539 images, 425 were correctly classified. Considering the adjacent severity level, only 4 images were misclassified (out of red dotted line).