A machine learning solution to predict foveal development and visual prognosis in retinal developmental disorders

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Introduction

Detecting and grading abnormal retinal development has important diagnostic and prognostic implications in children.[1,2] The foveal hypoplasia (FH) grading system is based on the stage at which retinal development ceases, and can be described as grade 1 to 4 FH and atypical FH (fig. 1).[1] Correctly identifying the degree of arrested retinal development requires an understanding of the developmental sequence and thus can be challenging for the non-expert (fig. 2). We therefore proposed the development of the first artificial intelligence (AI) based system to accurately identify and grade FH using optical coherence tomography (OCT).

Methods

(1) A representative sample (n=5078) of paediatric OCT scans demonstrating varying degrees of arrested retinal development were obtained from the Leicester OCT database (fig. 3).

(2) Foveal scans were acquired from table mounted (n=3037) and handheld OCT (n=2041) devices to develop a device agnostic system. The foveal B-scans were extracted, annotated, and segmented.

(3) A high-yield training dataset was inputted through a customised convolutional neural network (CNN) (ResNet-50) for the training stage.

(4) Following the training and fine-tuning of the customised ResNet-50, a validation stage to test the accuracy of the model was implemented.

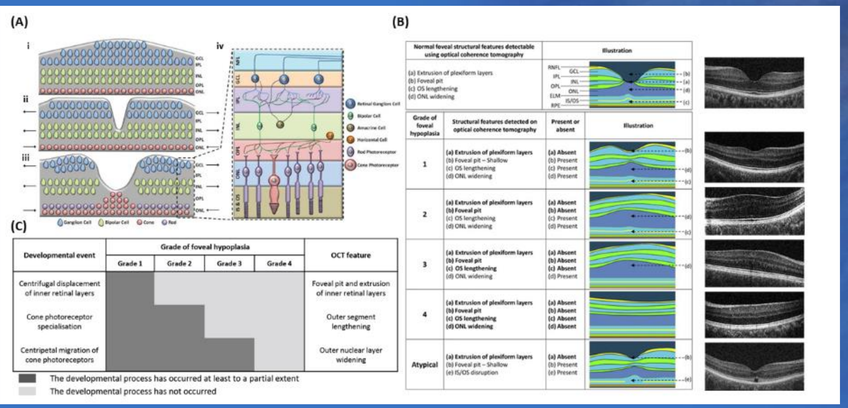


Figure 1: *(A) Schematic demonstrating the three foveal developmental stages. (B) The foveal hypoplasia grading scheme using OCT, with real foveal tomogram examples. (C) A schematic demonstrating the stage of arrested foveal development associated with the different grades of FH*

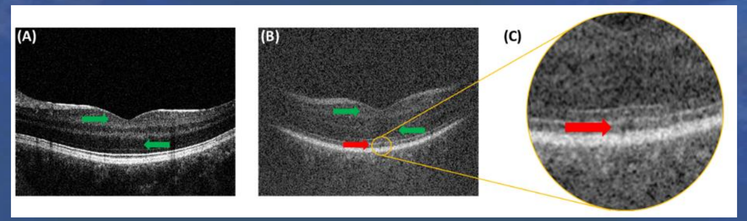


Figure 2: *(A) A foveal B-scan demonstrating grade 1 FH. (B & C) An example of atypical FH, with similar characteristics observed in grade 1 FH but demonstrating a subtle disruption of the inner segment ellipsoid.*

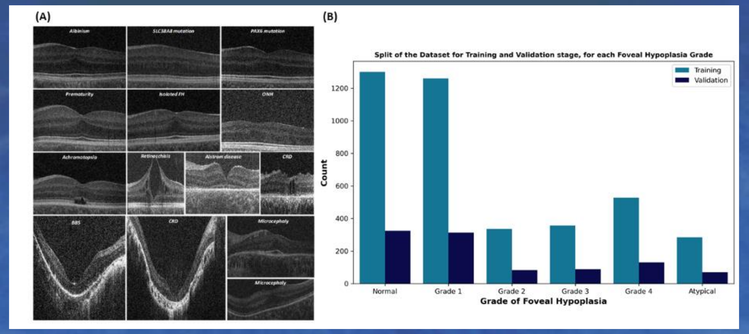


Figure 3: *(A) Examples of foveal abnormalities associated with different disorders, used in the development of the model.[3] (B) A breakdown of the weighting of groups in the training and validation of the model*

Results

Our binary classification (normal and abnormal foveal morphology) and six-point classification (normal, grade 1-4 FH and atypical FH) achieved 98.1% and 95.0% validation accuracy, respectively (fig. 4).

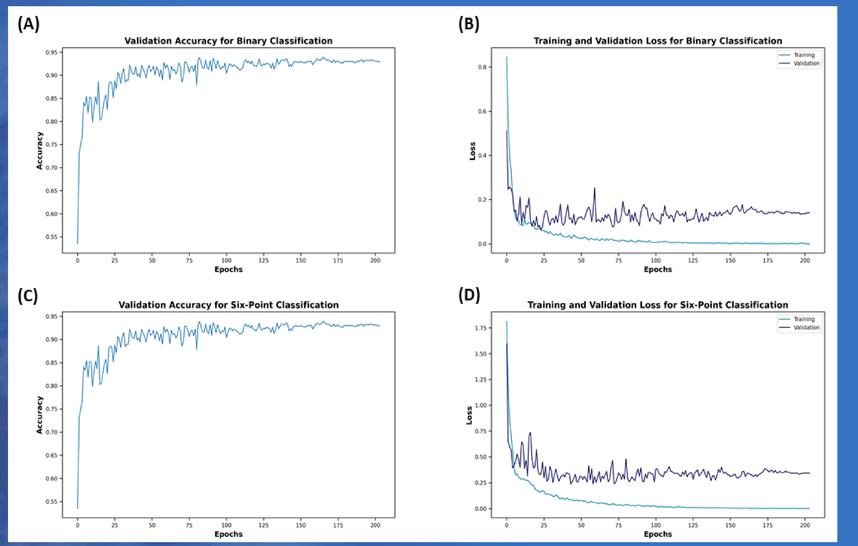


Figure 4: *Validation accuracy graphs for (A) binary classification (normal vs. abnormal) and (C) six-point classification (normal, grade 1-4 FH and atypical FH). Training loss graphs for (B) binary classification and (D) six-point classification.*

Discussion

We have demonstrated, for the first time, the proof-of-concept for the use of a device agnostic, automated AI system in paediatric OCT interpretation.

Our system can help to eliminate inter-examiner variability and augment the clinical pathway by increasing time efficiency during busy clinics.

Our AI system provides a strong foundation for the development of a real-time, frontline diagnostic tool for retinal developmental disorders.

References

1. Thomas MG et al. Ophthalmology. 2011 Aug;118(8):1653-60
2. Rufai SR et al. Ophthalmology. 2020 April: 127(4): 492-500
3. Thomas MG et al. British Journal of Ophthalmology. 2020 Nov (online ahead of print)