Machine Learning Quantification of Fluid Volume in Eyes with Retinal Vein Occlusion Undergoing Treatment with Aflibercept: The REVOLT study

Mohammad A. Khan, M.Sc.[1]; Simrat K. Sodhi, M.Sc.[2]; John Golding B.A.[4], Anuradha Dhawan, M.D.[4] ; Jonathan D. Oakley, Ph.D.[3]; Austin Pereira, M.D., M.Eng.[5]; Daniel B. Russakoff, Ph.D.[3] and Netan Choudhry, M.D., FRCS(C)[4,5,6]

[1] McMaster University, Ontario, Canada; [2] University of Cambridge, Cambridge, UK; [3] Voxeleron LLC, San Francisco, USA; [4] Vitreous Retina Macula Specialists of Toronto, Etobicoke, ON, Canada; [5] Department of Ophthalmology & Visual Sciences, University of Toronto, Toronto, ON Canada; [6] Cleveland Clinic Canada, Toronto, ON, Canada

PURPOSE

Retinal vein occlusions (RVOs) are the second leading cause of vascular blindness, where anti-VEGF agents are among the first-line treatment options. Recent developments in artificial intelligence (AI) models have shown promise in OCT fluid segmentation and predictive value in anti-VEGF treatment outcomes. However, there are currently no trials demonstrating AI with swept-source Optical Coherence Tomography (SS-OCT) images in concordance with OCT analysis for RVO patients.

METHODS

49 treatment-naive subject eyes were diagnosed with visual impairment due to RVOs, either central (CRVO) or branch (BRVO). SS-OCT data was used to assess retinal layer thicknesses, as well as quantify intraretinal fluid (IRF), subretinal fluid (SRF), and serous pigment epithelium detachments (PEDs) using a deep learning-based, macular fluid segmentation algorithm (Figure 1). Patients received 3 loading doses of 2 mg intravitreal aflibercept injections (IAI). Image analysis was performed at baseline, month 3 & month 6 follow-up. Baseline OCT morphological features and fluid measurements were correlated using the Pearson correlation coefficient (PCC) to changes in BCVA to determine which features most impacted 6-month change in BCVA. The area of non-perfusion in OCT-A images treated would also be evaluated through Ischemic Index computation (Figure 2).

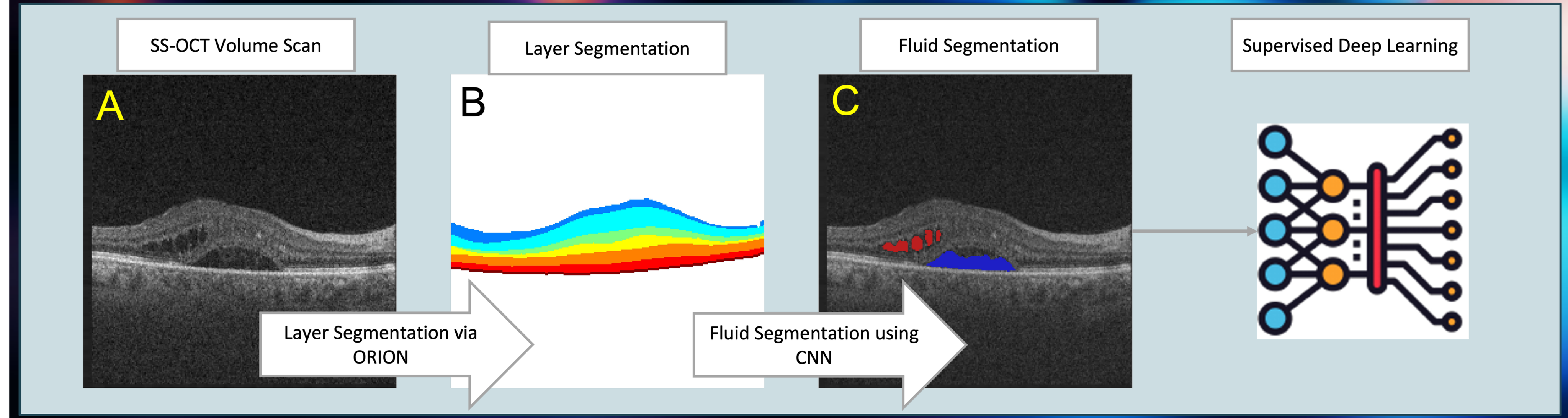

Figure 1: Each **(A)** SS-OCT volume scan is first automatically segmented using Orion into 8 retinal interfaces. This results in **(B)** 7 layers that can be encoded into image form and used as an additional channel in model creation, thus encoding spatial information regarding the location of **(C)** fluid within the retina.

RESULTS

A combined model of thickness in the Outer-Plexiform Layer (OPL), retinal nerve fiber layer (RNFL) and presence of IRF had the strongest overall correlation for CRVO (PCC=0.865, $p < 0.05$); while for BRVO the addition of IRF to the OPL-Inner Nasal model had a strong correlation (PCC=0.803, $p < 0.05$). Baseline Ischemic Index in the Deep Capillary Complex (DCP) for CRVO without denoising demonstrated notable correlation with 6-month change in BCVA (PCC=0.9101, $p < 0.05$).

RESULTS

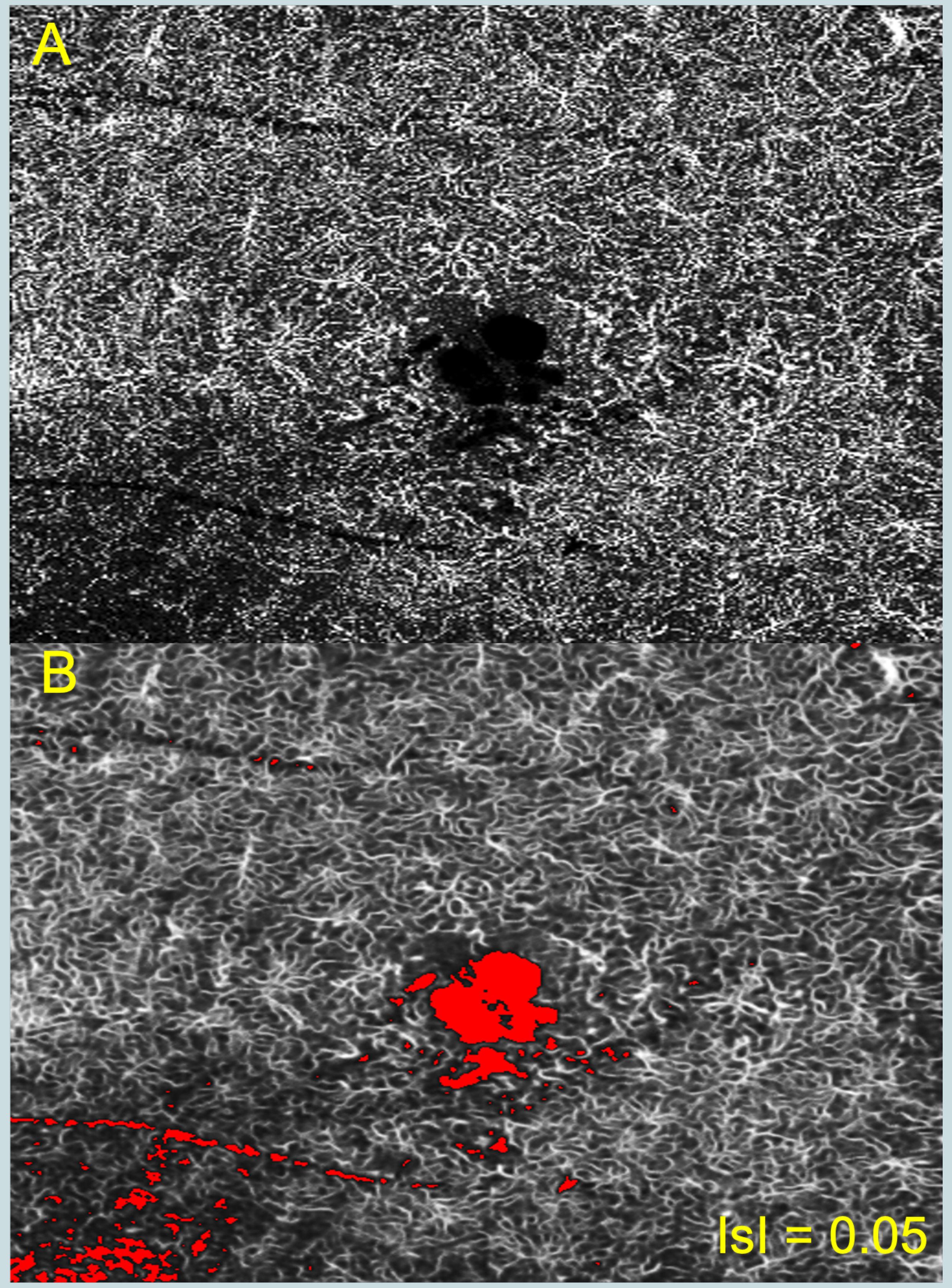

Figure 2: Ischemic Index (IsI) of the DCP in an OCT-A image for a CRVO patient visualization. The raw OCTA image is shown in (A). Non-perfused areas are highlighted in red in (B)

A

VARIABLE	ESTIMATE	STD. ERROR	P-VALUE
INTERCEPT	0.6255	0.3	0.0762
INTRARETINAL FLUID	$2.8x10^{-5}$	$6.8x10^{-6}$	$8.0x10^{-4}$
OPL THICKNESS	$-1.9x10^{-2}$	$6.1x10^{-3}$	$6.0x10^{-3}$
RNFL THICKNESS	$-7.4x10^{-3}$	$4.0x10^{-3}$	0.087
MODEL PCC	0.865		$4.84x10^{-5}$

B

VARIABLE	ESTIMATE	STD. ERROR	P-VALUE
INTERCEPT	0.324	0.138	0.0272
INTRARETINAL FLUID	$3.5x10^{-6}$	$1.6x10^{-6}$	0.038
OPL THICKNESS	$-1.3x10^{-2}$	$3.1x10^{-3}$	$2.0x10^{-4}$
MODEL PCC	0.805		$3.6x10^{-5}$

C

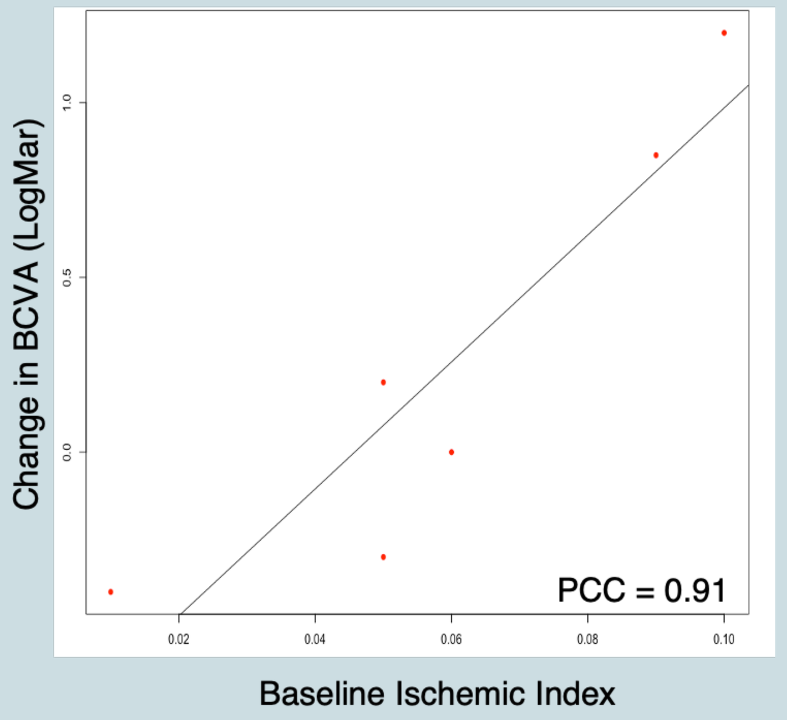

Figure 3: (A) Regression summary table of combined model including IRF, OPL Thickness and RNFL Thickness for the CRVO group **(B)** Regression summary table of combined model including IRF, OPL Thickness for the BRVO group. **(C)** : Comparison of Baseline Ischemic Indices to 6 month change in BCVA for CRVO patients.

CONCLUSION

A combined model of IRF and thickness, alongside ischemic indices provide the best correlation to BCVA changes. This is clinically consistent given that the DCP supplies the OPL, as macular fluid builds up, these vessels have reduced flexibility to accommodate; thus becoming more occluded, causing further damage to the OPL. Ultimately, an AI approach to analyzing fluid metrics may provide an advantage in personalizing therapy and predicting BCVA outcomes for RVO patients.

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