A Novel AI-Based Algorithm for Quantifying Volumes of Retinal Pathologies in OCT Scans

ePoster 503
AAO 2019
San Francisco, CA

Michaella Goldstein MD, Moshe Havilio PhD, Omer Rafaeli MD, Anat Loewenstein MD

Financial Relationships

- Michaella Goldstein, MD
  - [E] Tel Aviv Medical Center
  - [C,L] Allergan, Bayer, Novartis
  - [L] Roche
- Moshe Havilio, PhD
  - [E] Notal Vision
- Omer Rafaeli, MD
  - [E] Notal Vision
- Anat Loewenstein, MD
  - [E] Tel Aviv Medical Center
  - [C,O] Notal Vision
  - [C,L] Allergan, Bayer, BeyeOnics, ForSight Labs, Novartis, Roche

Introduction

- There is a growing clinical interest in automatic, Optical Coherence Tomography (OCT) based, retinal pathologies detection[1] and fluid quantification [2] for retinal disease management.
- The Notal OCT Analyzer (NOA), a novel Artificial Intelligence based algorithm, was developed to detect and quantify the volumes of Age-related Macular Degeneration (AMD)-related pathologies, including retinal fluid and RPE elevations, and to follow these volume quantities over time.

Objectives

- To evaluate the performance of the Notal OCT Analyzer (NOA) algorithm in detecting and quantifying the volume of retinal fluid in individual macular OCT images
- To evaluate the performance of the Notal OCT Analyzer (NOA) algorithm in detecting and quantifying the volume of RPE elevations in individual macular OCT images
- To analyze sequential macular OCT images in individual eyes and populations of eyes to follow volume quantities over time

Methods

Subjects: 172 eyes of 89 patients with exudative AMD
Time Frame: Sequential OCT image cubes were collected for up to 10 years in each patient
OCT Device: Heidelberg SPECTRALIS

Retinal Fluid Detection:

For presence/absence of retinal fluid, Intra-retinal fluid (IRF), and Sub-retinal fluid (SRF)

- 314 cubes were manually evaluated by a single human grader
- 271/314(86%) of cubes were evaluated by NOA
- 43/314 (14%) were excluded by NOA due to ineligibility

Retinal Fluid Quantification:

135 cubes containing retinal fluid, either IRF or SRF, were identified

- The fluid in 135 cubes was manually delineated by a single human grader and its volume quantified
- 155 cubes (135 cubes with fluid + 20 randomly selected cubes without fluid) were evaluated by NOA for Quantification-eligibility analysis
- 146 eligible cubes were fluid-volume quantified by NOA

RPE Elevation Quantification:

- 146 cubes evaluated by NOA for eligibility in Fluid Quantification analysis were evaluated for RPE Elevations
- In 146 cubes the largest RPE Elevation in a cube was manually delineated by a single human grader and its volume was quantified
- In 146 cubes the the largest RPE Elevation in a cube was identified by NOA

Retinal Volume Quantification in Sequential Images over time (Time Series Analyses):

- Analyses were performed on up to 10 years of images per eye

Results – Fluid Detection: NOA compared to Human Grader High Sensitivity and Specificity

Detection of Retinal Fluid: IRF and/or SRF			
	Positive	Negative	Total
Positive	127	10	137
Negative	8	126	134
Total	135	136	271
	0.94	0.93	

Detection sensitivity of 94%±4% (CI of 95%)

Detection specificity of 93%±5% (CI of 95%)

Detection of IRF			
	Positive	Negative	Total
Positive	86	20	106
Negative	9	156	165
Total	95	176	271
	0.91	0.89	

Detection sensitivity of 91%±6% (CI of 95%)

Detection specificity of 89%±5% (CI of 95%)

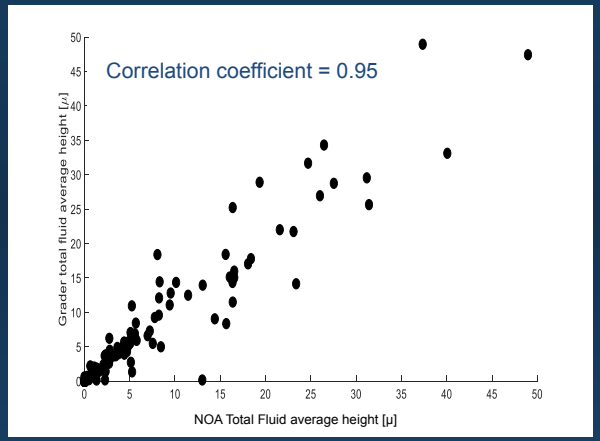
Detection of SRF			
	Positive	Negative	Total
Positive	83	15	98
Negative	11	162	173
Total	94	177	271
	0.88	0.92	

Detection sensitivity of 88%±7% (CI of 95%)

Detection specificity of 92%±5% (CI of 95%)

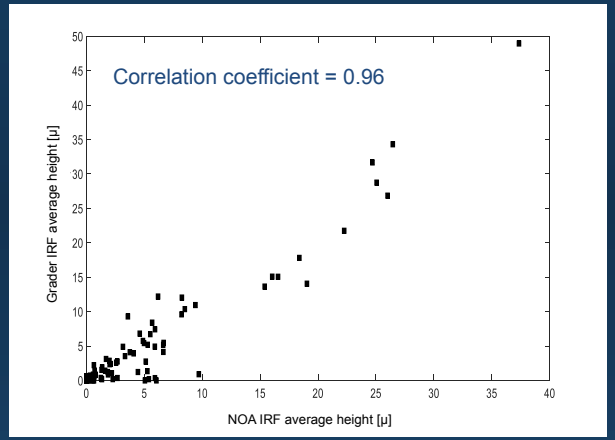
Results – Fluid Volume Quantification: NOA Compared to Human Grader High Correlation Coefficient

Total Retinal Fluid



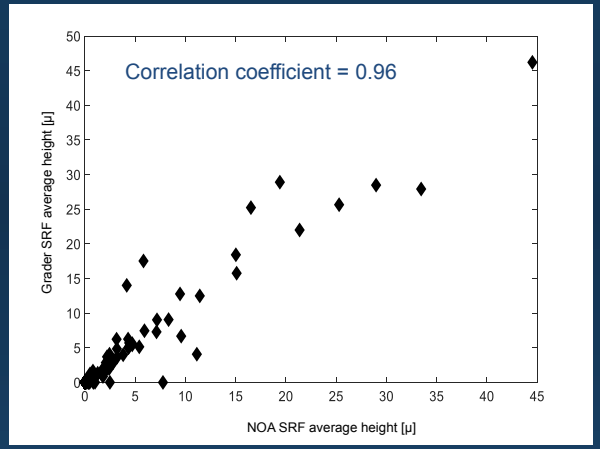
Correlation coefficient = 0.95

IRF



Correlation coefficient = 0.96

SRF

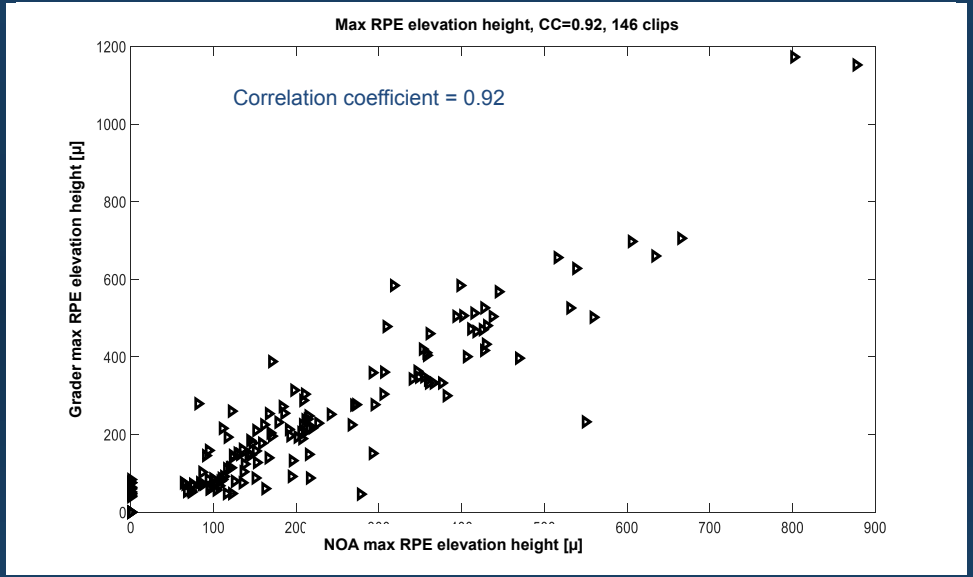


Correlation coefficient = 0.96

Fluid measured by average height (=fluid volume / cube area) in microns

Results – Maximum Height of RPE Elevation: NOA Compared to Human Grader High Correlation Coefficient

Maximum Height of RPE Elevation

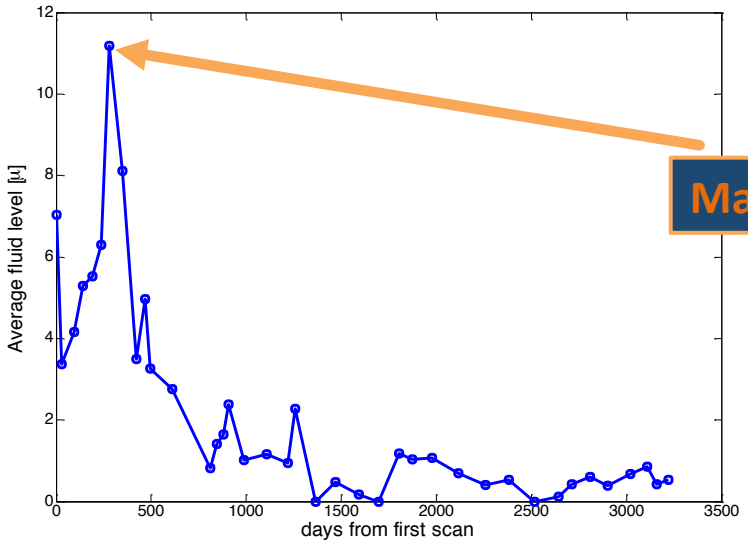


Correlation coefficient = 0.92

Height measured in microns

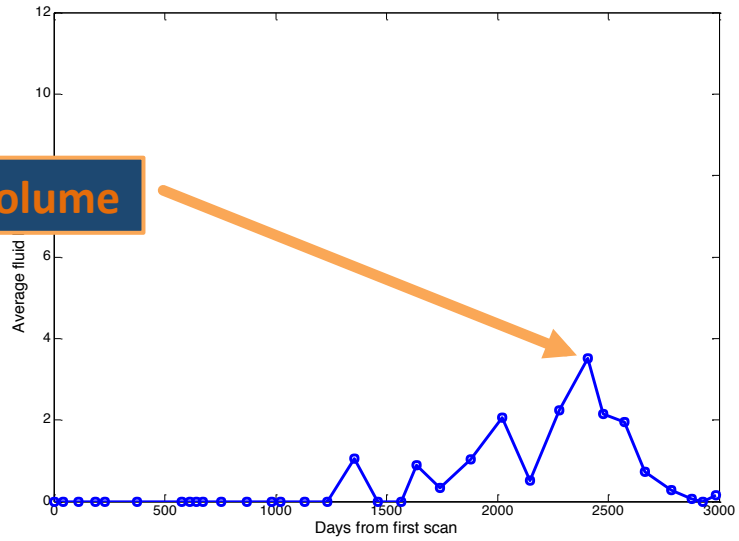
Results – Time Series Analysis of Fluid Volume, Each Eye, Single Patient
Benefit of Early Detection

CNV at Start



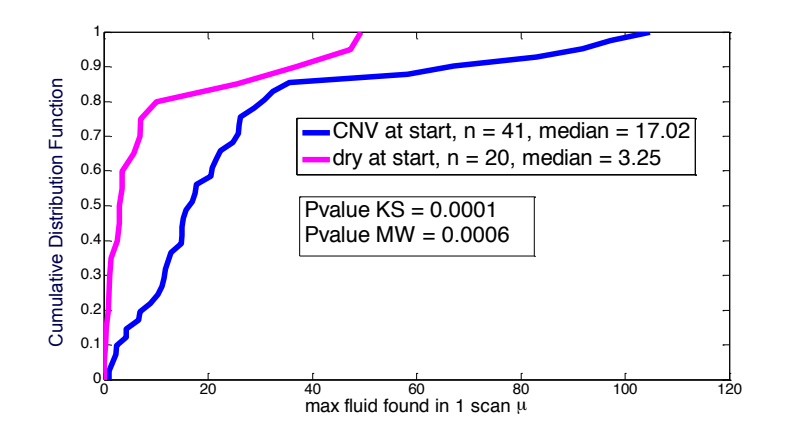
Max Fluid Volume

Dry at Start

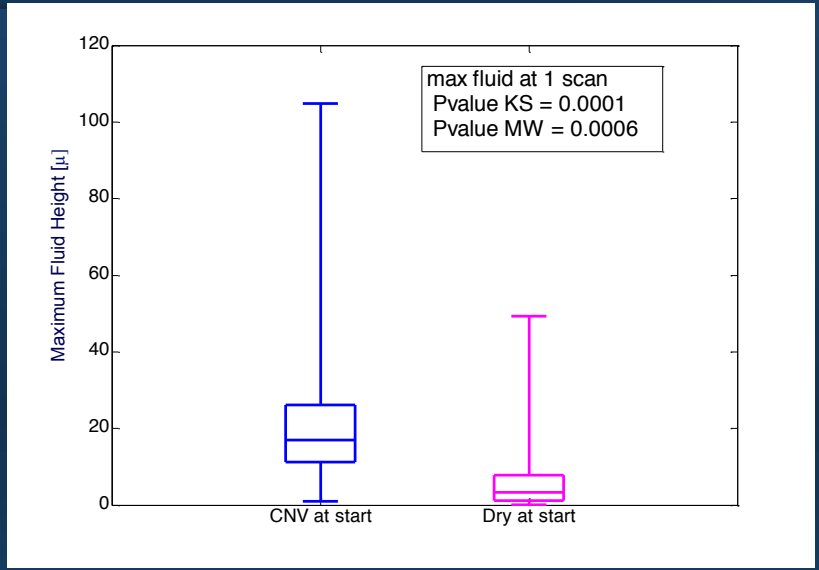


- Left eye was diagnosed on initial visit to the clinic with CNV and pre-existing fluid (“CNV at start” or late detection). A higher maximal fluid volume was reached even with treatment
- Right eye with dry AMD initially, which converted to CNV with fluid, detected during regular monitoring visits (“dry at start” or early detection). A lower maximal fluid volume was reached with treatment.

Results – Time Series Analysis of Fluid Volume, Population Benefit of Early Detection



KS - Two-sample Kolmogorov-Smirnov test
MW - Mann-Whitney test



Subjects / Methods

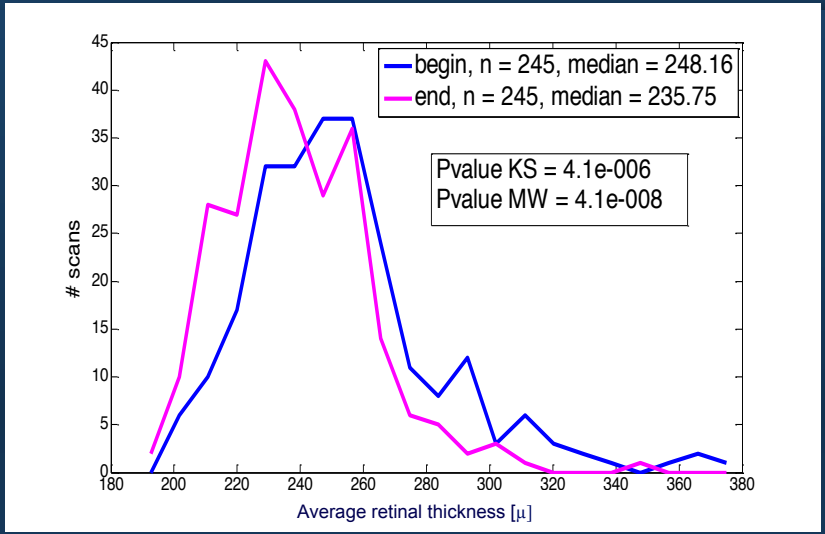
- 41 eyes diagnosed on initial visit to the clinic with CNV and pre-existing fluid ("CNV at start" or late detection)
- 20 eyes with dry AMD initially which then converted to CNV with fluid, detected during regular monitoring visits ("dry at start" or early detection). The fluid in these eyes was validated by a human grader.

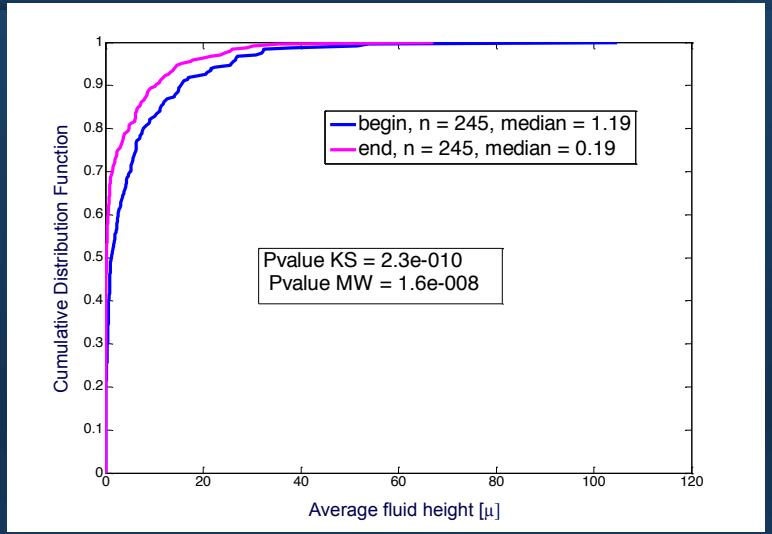
Key Findings

- The maximum volume of fluid was significantly higher in CNV eyes with late detection compared to those with early detection.

CDF = Cumulative Distribution Function

Results – Time Series Analysis of Retinal Thickness & Fluid Volume, Population Beginning vs. End of Treatment





KS - Two-sample Kolmogorov-Smirnov test
MW - Mann-Whitney test

Subjects / Methods

- 47 wet AMD patients diagnosed with retinal fluid
- >10 OCT cubes obtained over >1000 days
- First cube = at diagnosis with first treatment
- Last cube = last (or most recent) treatment
- "Begin"/"end" series = first/last 5 cubes if 10 or 11 cubes in total, first/last 6 cubes if > 12 cubes in total
- 245 cubes in each arm ("begin" series vs. "end" series)

Key Findings

- The average retina thickness and fluid volume were significantly higher at the beginning of treatment than at the end of treatment
- The fluid volume was also significantly higher at the beginning of treatment than at the end of treatment for the sub-groups of IRF and SRF (not shown)

  IRF, MW p= 1e-004

  SRF, MW p= 6e-005

Conclusions

- Notal OCT Algorithm (NOA) is able to detect retinal fluid with high sensitivity and specificity when compared to human graders
- NOA volume quantifications of fluid and RPE elevations are highly correlated with those by human graders
- NOA's ability to provide volume quantifications of fluid and RPE elevations over time may be a clinically useful tool in evaluating retinal disease status and progression over time

References and Contact Information

References:
[1] Chakravarthy, Usha, et al. "Automated identification of lesion activity in neovascular age-related macular degeneration." *Ophthalmology* 123.8 (2016): 1731-1736.

[2] Guymer, Robyn H., et al. "Tolerating subretinal fluid in neovascular age-related macular degeneration treated with ranibizumab using a treat-and-extend regimen: FLUID study 24-month results." *Ophthalmology* 126.5 (2019): 723-734.

Author Contact Information:

Michaella Goldstein, MD, Tel-Aviv Medical Center, michaellag@tlvmc.gov.il
Moshe Havilio, PhD, Notal Vision, moshe@notalvision.com
Omer Rafaeli, MD, Notal Vision, omer@notalvision.com
Anat Loewenstein, MD, Tel-Aviv Medical Center, anatl@tlvmc.gov.il