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Research Article

Artificial Intelligence-Based Automated Segmentation of Sub-Retinal and Sub-RPE Fluid in Patients with Chronic Central Serous Chorioretinopathy (CSC)

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Abstract

Background: Automated image analysis using artificial intelligence-powered software offers the promise of more efficient detection of ocular pathology. Accurately identifying both sub-retinal (SRF) and sub-retinal pigment epithelium (PED) fluid on optical coherence tomography (OCT) could be one way to aid clinicians and quantify disease over time. The accuracy of one such system was evaluated.

Methods: OCT volume scans of patients with central serous chorioretinopathy (CSC) who participated in the Short-Term Oral Mifepristone for Central Serous Chorioretinopathy (STOMP-CSC) study were read by the Pegasus system (Visulytix, London, UK) for both SRF and PED volumes. The results were then evaluated by two masked graders, and scored on a scale from 0-4. Quantitative analyses were performed, and qualitative notes obtained.

Results: 30 eyes were evaluated at 5 different time points; a total of 145 OCT volume scans were assessed. The mean score for the accuracy of SRF and PED detection were 3.5 and 1.9, respectively. The majority of scans were graded a 4 for SRF detection (81%), while PED detection was scored a 4 by both graders in only 37% of scans.

Conclusions: The Pegasus automated AI decision support system performed well to detect SRF and PED volume in a population of CSC patients, and may be helpful as a tool to identify and follow these patients over time. Expanded data sets may help further improve the detection algorithms.

Keywords: *Artificial Intelligence, Central Serous Chorioretinopathy*

Abbreviations

SRF: Sub-Retinal Fluid; PED: Sub-Retinal Pigment Epithelium Fluid; OCT: Optical Coherence Tomography; CSC: Central Serous Chorioretinopathy; STOMP-CSC: Short-Term Oral Mifepristone for Central Serous Chorioretinopathy study; AI: Artificial Intelligence; SHRM: Sub-Retinal Hyperreflective Material.

Introduction

Artificial intelligence (AI) based algorithms allow the promise of rapid detection, identification and analysis of ocular pathology [1]. Early studies suggest it could have a significant impact in the evaluation and management of ocular conditions such as diabetic retinopathy, age-related macular degeneration, retinal vein occlusion, central serous chorioretinopathy (CSC), and retinopathy of prematurity, among others [2-4].

CSC is a common but typically self-limited disease which can reduce central vision due to accumulation of serous fluid under the neurosensory retina leading to serous retinal detachment [5]. Diagnosis of CSC is made based on the clinical presentation and multimodal imaging, including optical coherence tomography (OCT), a non-invasive retinal scan, which can detect sub-visible volumes of intra- and sub-retinal fluid (SRF), as well as sub-RPE (PED) fluid [6-8]. Prior studies have proposed ways to automatically segment and quantify the volume of fluid in and under the retina, and the benefits that such quantification may offer to eye care providers and patients alike. Several systems are being developed to achieve these ends, though rigorous validation is required to ensure their accuracy across different diseases [4,9,10].

The Pegasus system (Visulytix, London, UK) is an automated AI decision support platform created to identify retinal pathology. In this study, the software was used to identify both SRF and PED in patients who had chronic CSC [11]. Its accuracy in detecting SRF and PED volumes was evaluated.

Materials and Methods

Volume scans of patients who participated in the Short-Term Oral Mifepristone for Central Serous Chorioretinopathy (STOMP-CSC) study (NCT02354170) were analyzed by the Pegasus system, which highlighted and pixel-quantified SRF and PED fluid on each individual B scan that comprises a volume scan. The accuracy of SRF and PED detection in each volume scan was given a grade from 0-4 by two masked evaluators. A grade of “0” represented 0-20% of fluid detected, “1” 21 - 40%, “2” 41-60%, “3” 61 - 80%, and “4” 81-100%. Separate grades were given for both SRF and PED detection accuracy. Basic statistical analyses performed included calculating mean, standard deviation, and paired sample t-tests. Qualitative notes were obtained to further characterize situations in which the software poorly detected SRF or PED fluid.

Informed consent was obtained as part of the STOMP-CSC protocol, which followed the tenets of the Declaration of Helsinki. No additional consent was required for this subsequent image analysis.

Results and Discussion

30 eyes were included and a total of 145 OCT volume scans were evaluated. The mean grade for SRF and PED detection was 3.5 ± 0.88 and 1.9 ± 1.7, respectively. SRF was graded a 4 in 81% (n = 117) of scans, while PED volume achieved a 4 in only 37% (n = 54) of scans (see Table 1). The difference in the accuracy of detection of SRF versus sub-RPE fluid was statistically significant (*p*-value <0.05).

Frequency (%)	SRF	PED
% of scans graded “0”	2.1	29
% of scans graded “1”	1.4	19
% of scans graded “2”	6.2	9.7
% of scans graded “3”	9.7	4.8
% of scans graded “4”	81	37
Average grade	3.5	1.9
Standard deviation	0.88	1.7

Table 1: *Frequency (%), mean, and standard deviation of SRF and PED in 145 volume scans.*

Both evaluators graded SRF equally in 71% (n = 103) of volume scans, while PED was graded equally in 63% (n = 91) of scans. Grading variability was noted to be higher in evaluating PED compared to SRF. Differences in the grading of the performance of Pegasus to accurately detect SRF or PED fluid was largely driven by situations in which only small amounts of fluid were present in either the subretinal or sub-RPE space, or when RPE clumping was present (see Figures 1 and 2).

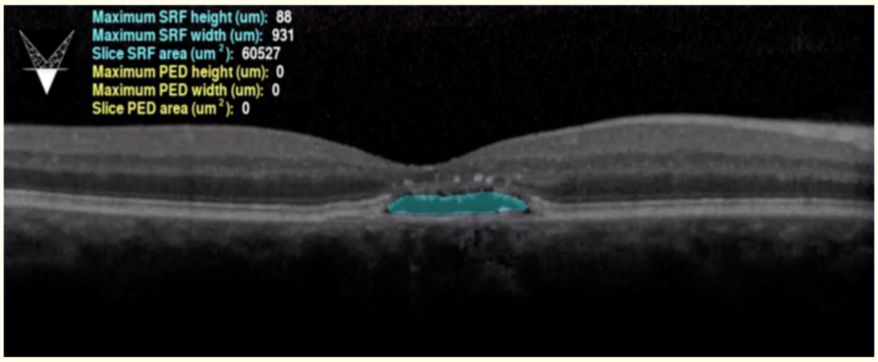

Figure 1: *Demonstration of the size discrepancy between SRF and PED. Note the flat-shaped and trace volume PED which goes undetected.*

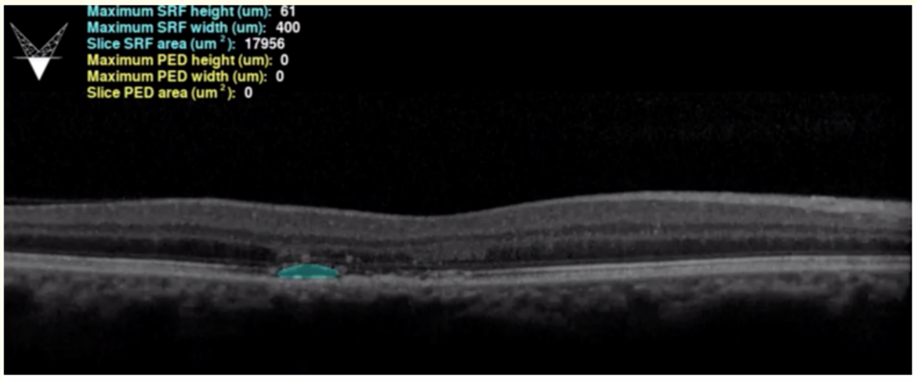

Figure 2: *Retinal pigment epithelial (RPE) clumping resembling trace PED.*

Conclusion

The Pegasus automated AI decision-support software was able to accurately detect sub-retinal and sub-RPE fluid in patients with chronic CSC. In our study, we found that SRF was more accurately detected compared to PED fluid. One reason which could explain this entails the relative differences in size between SRF and PED on a typical scan in this data set. An inclusion requirement to enter into the STOMP-CSC trial included the presence of SRF in the central macula, while no similar mandate was present for sub-RPE fluid [11]. As such, many scans in this data set contained a large volume of subretinal fluid with significantly smaller RPE detachments. In the few volume scans containing large PEDs, the software's performance was more accurate (see Figure 3).

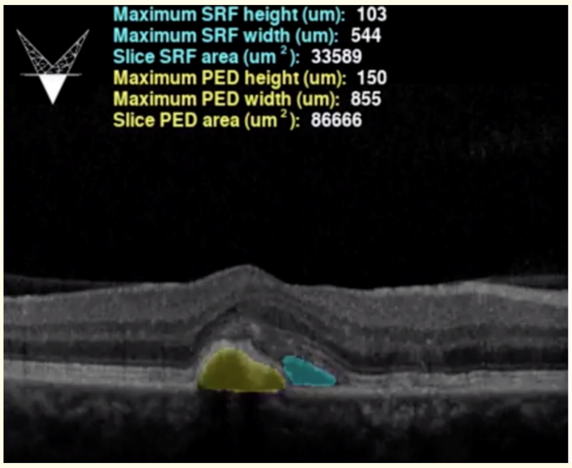

Figure 3: *Large volume PED which is accurately detected. Compare to Figure 1, which has small volume PED that goes undetected.*

In addition to volume differences, the shape of PED may have impacted the software's detection abilities. Many scans demonstrated low-lying or irregularly-shaped PEDs, which regularly went un- or under-detected by this AI system. The presence of RPE clumping presented yet another barrier to the overall accuracy of PED detection. However, there was also higher inter-observer variability for these small, irregular PEDs with pigment clumps, suggesting that human graders may also disagree on the "true" extent of the PED and sub-RPE fluid. In this way, the AI software mimicked the human graders. The Pegasus system performed better in detecting SRF, although the presence of sub-retinal hyperreflective material (SHRM) represented the most common hurdle for the accurate quantification of SRF (see Figure 4).

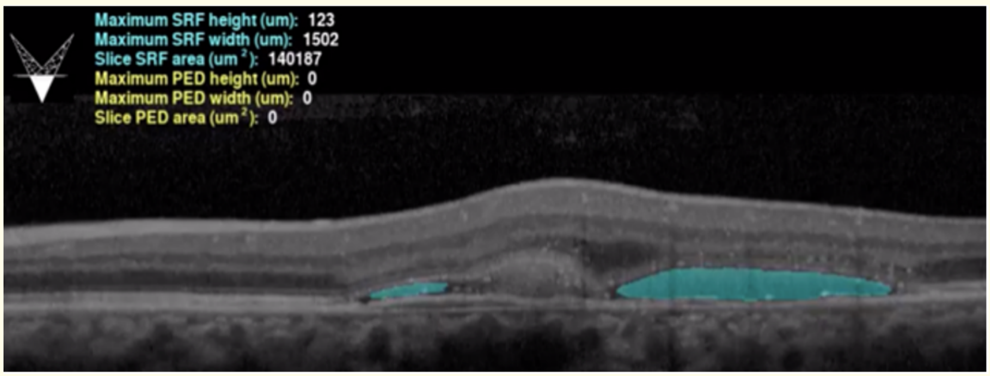

Figure 4: *Subretinal hyperreflective material (SHRM) obscuring accurate detection of large SRF.*

Larger data sets to train AI algorithms should help strengthen the detection algorithms for both SRF and PED, and highlight areas of irregularity, including RPE clumping and SHRM. Ultimately, these "decision-support" tools should be used in conjunction with clinical expertise; no doubt, they will continue to improve over time, as will their utility in both primary care and sub-specialty settings.

Conflict of Interest

There was no financial conflict of interest.

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