Augmented Reality Device Oculenz- Role in Improving Functional Vision in Patients With Age-Related Macular Degeneration

- Linda A. Lam, MD, MBA
- Thomas A. Finley, MD

OBJECTIVE To examine the functional visual outcomes using Oculenz Augmented Reality Device for patients with central scotomas secondary to severe age-related macular degeneration

PURPOSE A novel augmented reality (AR) headset Oculenz was designed for patients with advanced macular degeneration with central scotoma(s). Purpose was to examine capabilities and efficacy of Self-Calibration Visual Field Edge Detection Test and resulting Modified Real-Time Streaming Video (MRTSV) in AMD subjects performing tasks such as reading (logMAR and CNEC charts) and facial recognition.

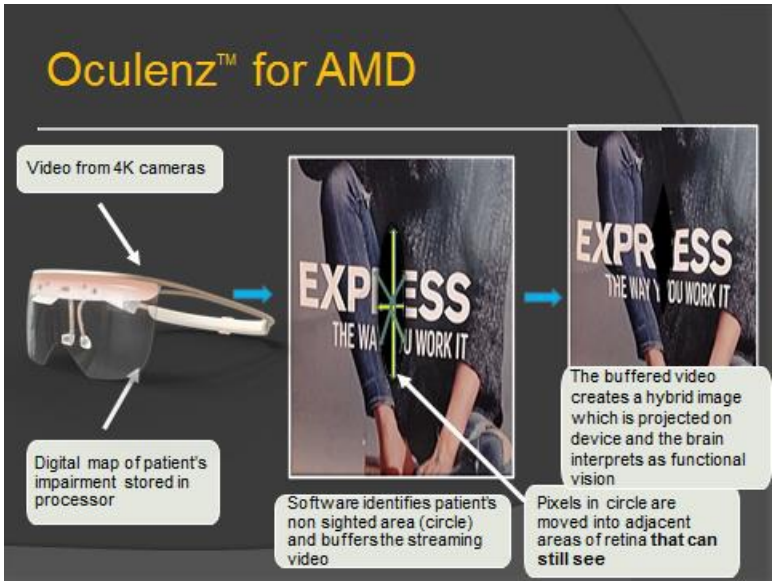
METHODS This study was a single arm, crossover study with 10 eyes (n=5) with advanced ARMD. Subjects performed Self-Calibration tests where Oculenz Augmented Reality (AR) device identified subject's scotoma that correlated area of non-vision with MRTSV. Self-Calibration result was compared to Fundus Autofluorescence of each eye. Reading performance was evaluated with logMAR chart, per eye, both pre-and post-headset use. Study consisted of imaging with Fundus Autofluorescence, headset training, and visual function tests prior to reading and facial recognition testing.

RESULTS Results showed subjects increased functional vision in reading logMAR eye chart and in facial recognition. BCVA was initially 20/200 improving to 20/80 with Oculenz without magnification. Without use of magnification, improvement up to 5 lines on logMAR chart was shown. While the Oculenz technique does not remove scotoma, by moving images

within geographical scotoma area to adjacent sighted retina areas, a person can see all letters of a word. The Oculenz AR device improved ability to read letters at near and far viewing distances in subjects with scotoma impairments from advanced ARMD.

CONCLUSION Results show Oculenz ARwear MRTSV method of pixel manipulation can enhance functional vision in patients with severe age-related macular degeneration. Oculenz headset provides a perceived de-emphasis of the scotoma and enhanced reading of letters in a word and improved recognition of faces of familiar individuals.

HUMAN RESEARCH Yes: Exempt from approval



Video from front-facing cameras on AR headset stores patient's area of impairment (scotoma) in processor. Software identifies patient's non-sighted area and buffers the streaming video to adjacent area of functional area. The resultant modified video is customized per eye based on software algorithms. Patient 'sees" the entire image which includes the area of vision that was previously missing. No central area or scotoma is perceived by the patient wearing the AR device.

Multicenter, head-to-head, real-world validation study of Artificial Intelligence Diabetic Retinopathy Screening Systems (AIDRSS)

- Aaron Y Lee, MD, MSCI
- Cecilia S Lee, MD
- Ryan T Yanagihara, MD
- Hoon Jung
- Yewlin E Chee, MD
- Michael D Gencarella
- Harry Jack Gee
- April Maa
- Mary Lynch
- Glenn Cooper Cockerham, MD
- Edward Boyko

OBJECTIVE Are AI algorithms ready to be deployed in US real-world DR teleretinal screening programs?

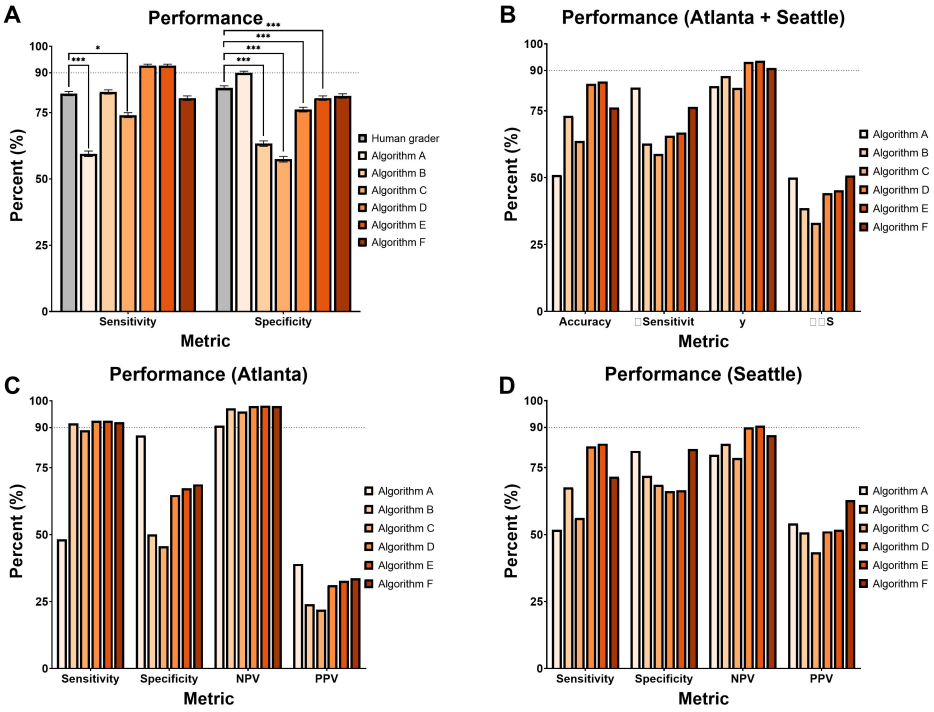
PURPOSE With the advent of deep learning, many companies have developed automated AIDRSS. As the FDA starts to approve such algorithms for clinical use, understanding their real-world performance is paramount. This multicenter study compared the performance and safety of existing automated AIDRSS using clinical data from two geographically distinct Veterans Affairs (VA) hospitals.

METHODS A total of 311,604 retinal images from 23,724 patients referred to the VA Puget Sound and the Atlanta VA teleretinal DR screening services from 2006 to 2018 were routinely acquired. All scans were used regardless of quality with no pre- or post-processing, as in real-life use. Of 20 invited companies, 6 algorithms (labelled A-F) were supplied. Each system graded all images into one of five stages ranging from no DR to proliferative DR (PDR), and ungradable image quality.

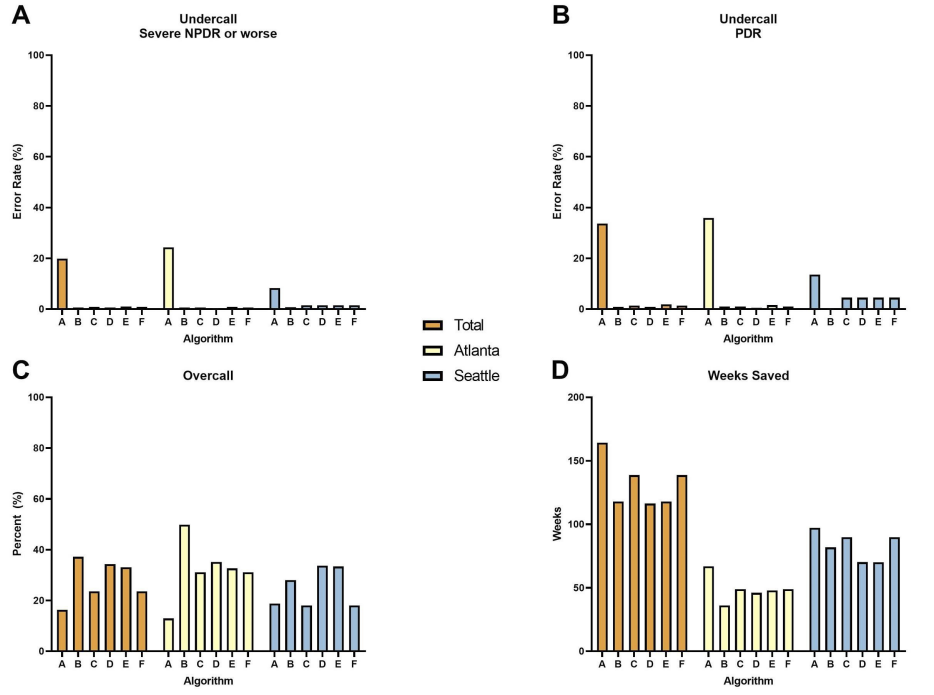
RESULTS More patients in Atlanta had severe nonproliferative DR (NPDR) or worse (2.7%) compared to Seattle (0.6%). The sensitivity (range 51.0%-85.9%), specificity (range 58.9%-83.7%), negative predictive value (NPV, range 84.2%-93.7%), and positive predictive value (PPV, range 33.1%-50.8%) for each AIDRSS were calculated and compared (Figure 1). Cases of severe NPDR or worse and PDR alone were under-referred at rates ranging from 0.6%-19.9% (Figure 2A) and 0.9%-33.6% (Figure 2B), respectively. The rates DR was overcalled ranged from 16.3%-41.1% (Figure 2C). Work-weeks saved ranged from 116.3-164.2 (Figure 2D).

CONCLUSION All algorithms achieved high NPVs, performing positively from a screening perspective. However, large variations in safety and specificity exist. Our results highlight the need for independent validation studies before clinical use.

HUMAN RESEARCH Yes: Approved by institutional review board



The performance of Algorithms A-F. (A) shows sensitivity and specificity of each algorithm compared to human graders with standard error bars against a subset of double, masked arbitrated grades. (B-C) shows the sensitivity, specificity, NPV, and PPV for each algorithm using images from Atlanta and Seattle (B), Atlanta alone (C), and Seattle alone (D). *, p≤0.05; ***, p≤0.001.



The safety and efficiency of Algorithms A-F. (A) and (B) shows the frequency that severe nonproliferative DR (NPDR) or worse (A) and PDR only (B) was inappropriately under-referred. (C) shows the rate that DR was classified as a higher stage DR than no

DR. (D) shows the time saved by using each algorithm in a two-stage screening system.

Translational Applications of Deep Learning in Retinopathy of Prematurity

- J. Peter Campbell, MD, MPH

OBJECTIVE The objective of this paper is to explore potential applications of deep learning in retinal disease beyond image-based pattern recognition using retinopathy of prematurity (ROP) as an example.

PURPOSE ROP is a leading cause of childhood blindness worldwide, but screening is labor intensive and clinical diagnosis is subjective and qualitative. This study describes the use of deep learning to develop objective and quantitative biomarkers for ROP, and evaluates potential applications for monitoring disease progression, response to treatment, epidemiology, and education.

METHODS Deidentified images (RetCam; Natus Medical Incorporated) captured after clinical examinations between July 2011 and December 2016 were assessed as part of the Imaging and Informatics in ROP (i-ROP) cohort study. A deep learning system was used to classify the probability of an image having a reference standard diagnosis of plus disease, and converted to an automated 1 (most benign) to 9 (most severe) scale using published methods. Quantitative scale values were analyzed for 5255 clinical examinations in 871 infants and reported using descriptive statistics. Inter- and Intra-examiner variability in diagnosis, and differences between hospitals were assessed using the quantitative scale.

RESULTS A higher vascular severity score was associated with more posterior disease ($p<0.001$), higher disease stage ($p<0.001$), and more clock hours of stage 3 ($p<0.001$). When long-term differences in the median severity scores across time between the eyes progressing to treatment and those who did not eventually require treatment were compared, the median score was higher in the treatment group at all time points ($p<0.001$). Mean (±SD) vascular severity scores significantly increased 2 weeks prior to treatment (4.19 [±1.75]), peaked at treatment (7.43 [±1.89]), and decreased for at least 2 weeks after treatment (4.00 [±1.88]) (all $p< 0.001$). At the examiner level, we found quantitative

differences both between and within examiners in the level of disease diagnosed as plus disease. At the hospital level, we found differences in the level of ROP between hospitals, however these were not significantly different when controlled for demographic risk factors.

CONCLUSION Deep learning may facilitate quantiative diagnosis of retinal diseases like ROP. The ROP vascular severity scale corresponds with current clinical classifications of disease severity and may enable quantitative disease monitoring in the future. In addition, the use of a quantitative scale may facilitate population level assessment of disease burden, and standardize treatment thresholds between clinicians. Similar applications may be possible in other disease states and imaging modalities using deep learning to generate quantitative disease biomarkers that correlate with qualitative classification systems.

HUMAN RESEARCH Yes: Approved by institutional review board

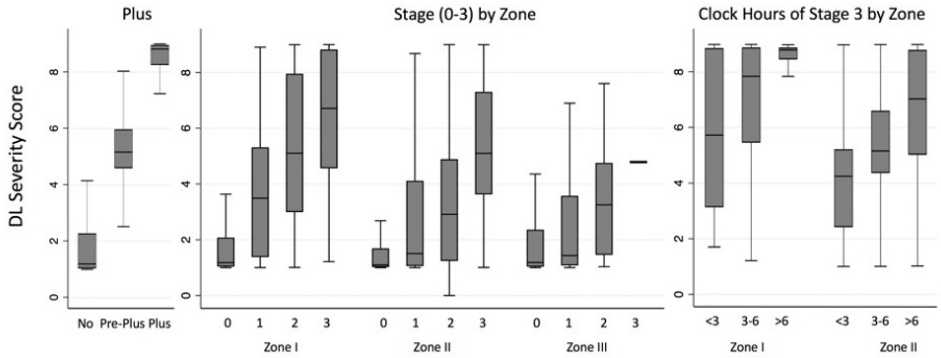


Figure 1. Deep learning (DL) derived vascular severity score as a function of zone, stage, extent, and plus disease. A higher severity score correlated with more posterior disease, higher stage of disease, and a higher extent of stage 3 ROP.

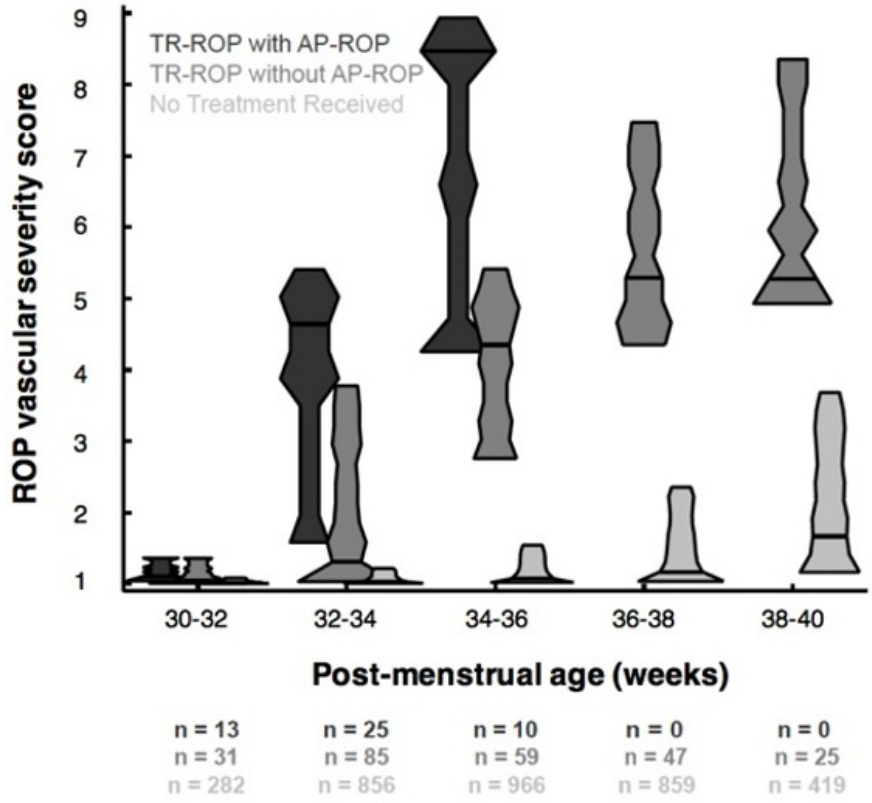


Figure 2. Longitudinal evaluation of ROP vascular severity score over time. Patients diagnosed with aggressive posterior ROP (AP-ROP) demonstrated earlier and more rapid rate of progression than patient who developed treatment requiring (TR) ROP without AP-ROP, and those who did not receive treatment. These results suggest that the use of quantitative monitoring may facilitate early detection of babies progressing towards severe ROP. (Smith et al, Ophthalmology In Press).

Time Independence, Optimized Surgical Steps - The Promise of Robotics

- Richard B. Rosen, MD, DSc(Hon)
- Reza Ladha, MD , FEBO
- Marc D. de Smet, MDCM, PhD, FRCSC, FARVO

OBJECTIVE Demonstrate the advantages of high precision robotics in retinal delivery over manual technique

PURPOSE Robotics provides high positional stability as well as micrometer precision and accuracy in XYZ. This removes any time constraint on drug delivery within the retinal space, whether intracannular or subretinal. It also allows for a detailed analysis of each phase of a surgical procedure and its optimization.

METHODS The following exemplifies our approach to procedure optimizations. To optimize subretinal delivery, first in vitro models are used such as freshly harvested porcine eyes, in which a standard pars plana vitrectomy with IOP control under microscopic visualization through a Rescan 700 Zeiss device was performed. Subsequently, subretinal injection using a 41G Teflon needle, was executed with or without the Preceyes Surgical System (PSS). The following parameters were recorded: absence of a Bruch's membrane breech, initiation success and duration to subretinal bleb creation. Surgical iOCT and microscopic recording where analyzed and categorized after completion of the surgery . Surgical success was defined as a creation of a subretinal bleb confirmed by intraoperative oct, while avoiding reflux. These were followed by studies in live anesthetized animals using similar parameters.

RESULTS No breech of Bruch's membrane was observed using either manual or robotic assistance. While static positioning was possible manually in the subretinal space, repeated contact with Bruch's was observed due to physiologic hand tremor. There was no motion while using the PSS. Surgical success was achieved in 80% of PSS assisted surgeries (blebs creation in 100%, with leakage in 20% at the time of retraction). With manual surgery, leakage was observed in all cases, in only 40% of cases could a bleb be successfully created. Leakage was observed at all stages of bleb initiation, injection and retraction of the needle. Time involved in belb generation was longer while using the PSS which may have bearing on the success.

CONCLUSION Removing any time constraint on delivery, providing high precision positioning allows for controlled delivery of substances to the appropriate targeted space. Given the stability of the robotic system, it is possible to carefully analyze the surgical procedure using existing iOCT technology. In fact, combining the robot with an iOCT appears to be the ideal optimal use of both technologies and requires further exploration.

HUMAN RESEARCH No: Study does not involve human research