

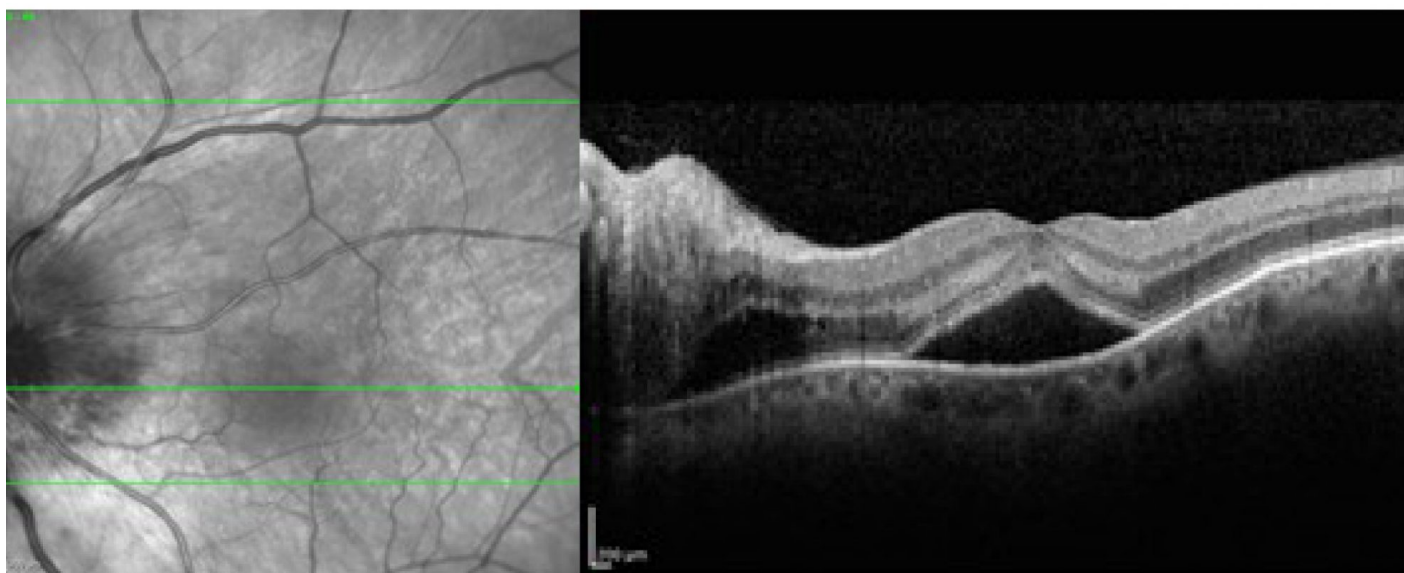
Optometric Education: Volume 46

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OPTOMETRIC EDUCATION

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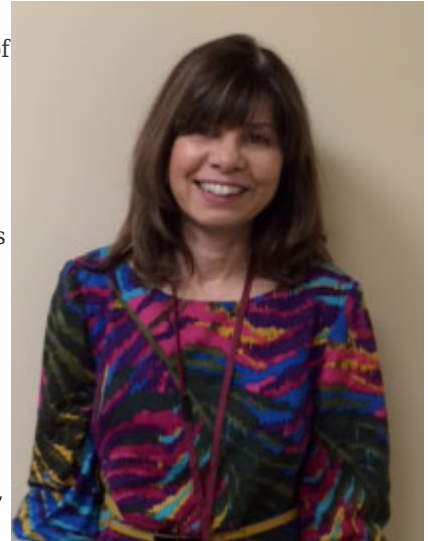
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Education Research and the Institutional Review Board (IRB)

Aurora Denial, OD, FAAO, DipOE | Optometric Education: Volume 46 Number 1 (Fall 2020)

In an effort to support better teaching and learning, faculty are often revising courses and instituting new teaching methodologies. In some instances, data collected as part of the course assessment demonstrate that the new methodology had a positive impact on learning. Is this considered education research if the faculty member now wants to share the new methodology and test scores with colleagues by publishing the results in an education journal?

The project definitely meets the definition of research, which includes “Research means a systematic investigation, including research development, testing, and evaluation, designed to develop or contribute to generalizable knowledge.”¹ The project also involves human subjects. A human subject included in research is defined as “A living individual about whom an investigator (whether professional or student) conducting research: 1) obtains information or biospecimens through intervention or interaction with the individual, and uses, studies, or analyzes the information or biospecimens, or 2) obtains, uses, studies, analyzes, or generates identifiable private information or identifiable biospecimens.”¹ As soon as the faculty member decides to share the results, they become generalizable knowledge. Collecting test scores provides important feedback for course revision and evaluation, but disseminating the information reclassifies the collection of information as education research. As education research, does this project require Institutional Review Board (IRB) review?



Aurora Denial, OD, FAAO

What is the IRB and How Does it Impact Education Research?

The IRB was developed in response to the unethical treatment of human subjects in research, including what occurred in the federally funded Tuskegee Syphilis Study, which was conducted from 1932 to 1972. Study subjects did not receive treatment and were not informed that an effective treatment for syphilis was available. In 1974, the National Research Act was signed into law and required institutions to have a board of at least five members that reviewed research on human subjects. Such boards are most commonly called IRBs. The Common Rule, which is a set of federal guidelines for the ethical conduct of human subjects, guides the review board.

IRBs vary in size and how they implement the Common Rule. An IRB must contain at least five members from varied professions whose purpose is to “protect the rights and welfare of the subjects involved in research.”² IRBs are composed of members who have expertise in science, one member who is not affiliated with the institution, and one member whose expertise is in a nonscientific area. The IRB has the authority to “approve research; disapprove research; modify the research; conduct continuing reviews of the research on at least an annual basis; observe, verify, and approve any modifications to the research; observe the consent process and research procedures; and suspend or terminate approval for research.”² IRBs are directed by the Common Rule but may vary in how they meet federal regulations and standards.

There are three types of IRB review: 1) full-committee, 2) expedited, and 3) review for exemption. Full-committee reviews are needed for studies that have risks that are more than minimal or involve vulnerable subjects. Expedited reviews are for projects that involve no more than minimal risk. Reviews for exemption pertain to studies that involve minimal risk and protect the identity of subjects. A full list of potentially exempt research can be found at the Department of Health and Human Services website along with decision-making charts to aid in determining whether potential research is exempt (<https://www.hhs.gov/ohrp/regulations-and-policy/decision-charts-2018/index.html#c4>).

Education research usually requires IRB review because it meets the criteria of research with intervention and human subjects. In some circumstances, education research may qualify for the exempt category. The federal guidelines do not specify who at an institution must determine that research is exempt. At some institutions, the principal investigator (PI) can determine whether a project is exempt using the decision tree. Although it may not be required, it is generally recommended that PIs ask for an IRB opinion on exemption. Many faculty have little research training and experience and can benefit from the expertise of the IRB. Education research involving students or residents as subjects may potentially put the subjects at risk due to power differentials. Subjects must participate in education research voluntarily, without coercion, and be allowed to withdraw.³

When in Doubt, and Even when Not, Consult the IRB

Investigators involved in education research should become familiar with the IRB protocols and policies involving education research, including subject recruitment, informed consent and confidentiality practices.³ When planning a course or project, consider the possibility of future publication and seek guidance from the IRB while still in the planning stage. When in doubt, and even when not, consult the IRB. Additionally, journals may require IRB review of education studies before publication. IRBs must follow the Common Rule but how that is implemented may vary. It is important to know your IRB and follow all protocols.

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A Novel Approach to Clinical Education through Distance Learning

Stephanie L. Adams, OD, PhD, and Elizabeth Wyles, OD, FAAO | Optometric Education: Volume 46 Number 1 (Fall 2020)

Background

During the unprecedented circumstances of the coronavirus disease 2019 (COVID-19) pandemic, professional education was forced to shift to distance learning to maintain student safety and limit the spread of disease while still advancing the students through the curriculum. The interruption of clinical encounters was arguably the greatest challenge for the continuation of optometric clinical education. Novel uses and adaptations of technology surged in the health professions so that clinical training could continue remotely.¹⁻⁶ The virtual clinical encounter (VCE) described here is one such novel adaptation. It creates an interactive learning experience using student collaboration, learner-generated content and detailed discussion.

The use of patient simulation in clinical education predates COVID-19. Simulated patient encounters in higher education, most commonly in schools of medicine and nursing, have been increasingly utilized to foster student collaboration, support learning outcomes and improve patient outcomes and survival.⁷⁻¹² A wide variety of simulation methods are used to create realistic clinical scenarios, from computerized mannequins to virtual patient role play.^{7,8,12} Simulated patient encounters offer students engaging clinical experiences to build skills in a safe and supervised environment at reduced costs compared with standardized patients played by actors.^{7,10} Close monitoring of the simulated clinical experience by educators allows them to provide valuable feedback to help students connect theory to practice, a requirement for success in clinical practice.¹⁰

Although computer-based clinical activities have been described in optometric education, their complex methodology using custom-developed software is not readily reproducible, making adoption by other institutions difficult.^{11,13} To guide the needed expedited development of virtual clinical activities, a search for peer-reviewed methodologies in the Education Resources Information Center (ERIC) via an EBSCO database was conducted using terms “optometry simulated patient,” “optometry patient simulation,” “optometry patient simulator” and “optometry virtual patient.” The search revealed no relevant optometric teaching methodologies since 1990 when problem-based learning was incorporated into the optometric curriculum.¹⁴ The lack of an available optometric patient simulation method led to the realization of the need to develop a technology-based VCE in order to continue clinical education during required social distancing in Spring 2020.

When incorporating technology into education, the SAMR (Substitution, Augmentation, Modification, Redefinition) model can be used to predict overall impact. The SAMR model of technology integration describes enhancement of existing teaching practices using technology that leads to the conception of new methodologies not previously possible.¹⁵ While originally described for use in K-12 programs, this hierarchical model has been applied in higher education including optometry.¹⁶ The enhancement areas of substitution and augmentation introduce a technological element that does not significantly alter the original activity. Substitution simply replaces a learning activity with a technology-based tool without functional change, such as using digital instead of paper study guides. Augmentation describes implementing a technology-based tool that results in a functional advantage, such as the use of online recorded lectures available for review with adjustable playback speed. The transformative areas of modification and redefinition require a higher level of task design inducing student collaboration and resulting in new learning experiences. Modification describes substantial redesign of a learning activity, for example, using a 3D anatomy mobile application for students to each learn a bone of the orbit and then teach their peers. The highest level of the SAMR model, redefinition, creates new tasks not previously possible, such as developing an interactive virtual patient encounter. While some caution that overemphasis on technology may distract from teaching, the SAMR model framework leads to novel learning activities that are possible only with the use of technology.^{16,17}

The demand for a fully remote clinical education combined with an understanding of previously accepted simulation and technology-based pedagogies in professional education fueled the development of the VCE for optometric student clinicians using videoconferencing, student collaboration and learner-generated content. The intent of the described methodology is for students to apply procedural and didactic knowledge in a closely monitored simulated patient encounter using critical thinking and clinical reasoning, and to enhance these skills using detailed feedback. Although the VCE was born out of necessity, incorporating this interactive activity into traditional clinical education provides an opportunity to develop students' clinical reasoning skills leading to improved clinical competency.

Methods

The VCE is currently utilized for second- and third-year students enrolled in primary care optometric clinical training. Students

in groups of four to six conduct a VCE within a predetermined time limit consistent with their level of training. The entire activity spans two remote clinical sessions and uses additional assignments to be completed outside of clinic time (**Figure 1**).

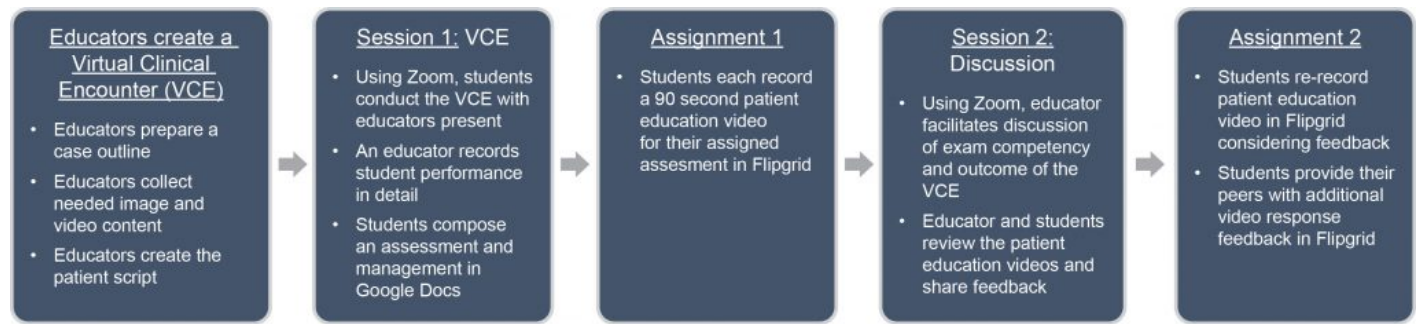


Figure 1. Outline and brief description of virtual clinical encounter (VCE) activities. [Click to enlarge](#)

The VCE is conducted in real time using videoconferencing, which concludes with students composing a formal assessment and management plan in a shared online document during the first clinic session. Following completion of the VCE, each student clinician records his or her patient education using video sharing. ([Second-year student's initial patient education on allergic conjunctivitis following a VCE in week 1.](#)) Peers and preceptors review the patient education videos during a subsequent discussion session. After the discussion session, students re-record their patient education videos. ([The same student's second attempt at patient education on allergic conjunctivitis after the discussion session in week 2.](#))

Instructions to students

Students are required to enable their audio and video features in the videoconferencing application to ensure all are actively participating. Suggested time for the VCE may vary from 45 minutes to 2 hours depending on student clinical skill level and case complexity. Students receive the following instructions at the start of the activity:

For your virtual clinical encounter (VCE) you will be working together as a group. You have 1.5 hours to conduct an eye exam on your patient, so please keep track of time. Have paper and a pen or equivalent ready to record your exam findings as no digital or hard copy will be provided. You need to give the patient instructions, verbalize equipment setup, and verbalize your exam findings for each procedure. Your group should work together and discussion is encouraged as you move through the exam. The group must unanimously agree to obtain each test or procedure requested. For example, if one clinician mentions they want to obtain a macular OCT, it is not provided unless all group members verbally agree. All requested information will be presented in images or videos for your interpretation. In your VCE you do not consult with a preceptor. Only perform the tests you consider necessary, keeping efficiency in mind.

At the end of the exam, the group must reach a consensus to release the patient after all requested tests and questions have been answered. The group should then compose an assessment and management in Google Docs to be completed before you leave the session. Evenly divide the assessments you have determined across the group members. Each group member will be responsible for providing the corresponding patient education for their assigned assessment in a recorded video on Flipgrid, due within 48 hours of the session. Your Flipgrid videos will be reviewed by your group and preceptor during the discussion of your clinical performance next week.

Faculty and session responsibilities

The first clinic session ideally uses two educators to facilitate the VCE. One educator (educator #1) plays the voice of the patient and presents the [prepared album of case images and videos](#) as requested by the student clinicians, while the other educator (educator #2) takes detailed notes and serves as overall facilitator as needed. A comfortable environment is needed for the students to verbalize their thought process during the VCE. In less vocal groups educator #2 may need to intervene, interrupting the student autonomy of the activity, in order to facilitate discussion or next steps. Emphasizing detailed VCE instructions, including the requirement for students to verbally request needed tests, instruct the patient and state the exam findings, are important for stimulating continued student discussion. As the exam unfolds, students may need to be notified of limitations in available equipment in order to redirect them to the most meaningful tests. For instance, with no available autorefractor, students are guided to perform retinoscopy. The educators must remain cognizant of the VCE instructions, letting the students verbalize equipment setup and patient instructions before revealing the indicated image or video. Educator #2 documents a thorough transcription-like record of the VCE, including but not limited to individual student contributions to case history, patient communication, sequence of procedures, ancillary test selection, interpretation of presented data and

application of knowledge as it relates to the formulation of diagnoses and associated management.

In the second clinic session, educator #2 facilitates the discussion forum to evaluate the VCE record of student performance and review the students' patient education videos. During the discussion the students are encouraged to carefully consider their choices regarding efficiency, test selection, diagnosis and management. This encourages them to critically evaluate their clinical decisions and knowledge base in a constructive environment. This type of discussion allows for the optometric institution's clinical evaluation rubric to be followed when assessing the students' performance in the VCE.

Purposeful pairing of faculty, such as clinicians from different specialties or a junior clinician with an established faculty member, may encourage more comprehensive and creative case content as well as foster faculty development. Pairing a basic science educator with a clinical instructor may also be advantageous. If utilizing two educators is not feasible, a teaching assistant may be an excellent resource, replacing educator #1, to help facilitate the VCE. Alternatively, if using a single educator for both roles, the VCE can be recorded and reviewed later in preparation for discussion.

Distance learning platforms

The technology required to successfully facilitate a VCE includes a videoconferencing platform, a slideshow presentation tool, an online shared document with real-time editing capability and a video-sharing application. While many tools are available for performing these tasks, the authors use the following platforms.

- Zoom ([Zoom Video Communications, San Jose, Calif.](#)). Videoconferencing hosts the student group and facilitates the presentation of requested image and video-rich exam data as the students navigate the VCE. Videoconferencing is also needed for the detailed discussion and review of the patient education videos the following the clinic session. Zoom is an affordable online software platform for virtual communication in video, phone or chat form, which the authors use to facilitate the activities. In Zoom's "gallery view" all participants can visualize and communicate with each other simultaneously using their electronic device's camera and microphone. During the VCE, educator #1 uses the screen-share function to present the exam data according to the students' requests. Importantly, the Zoom videoconference can continue without the host present, as both educators will eventually exit to allow the students to complete the associated VCE assignment as a group.

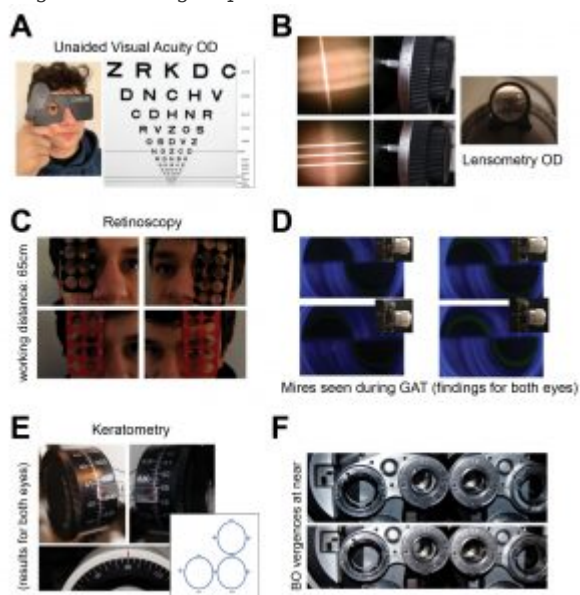


Figure 2. Examples of VCE album images presented for student

interpretation and documentation. (A) The image for unaided visual acuity at distance is presented as educator #1 reads the appropriate letters with planted errors. (B) Once the student clinicians request lensometry of the habitual glasses, the group is presented with the sphere and cylinder mires, drum and axis wheel reading. (C) Retinoscopy findings are presented with the neutralizing lenses highlighted. (D) A variety of Goldmann tonometry mires seen during the applanation process are presented; students must select the correct alignment to record the accurate reading. (E) Keratometry readings are presented with the horizontal and vertical drum, axis and illustrated mires. (F) Base-out vergences at near, performed in the phoropter, are presented after students properly describe the equipment setup and instruct the patient; educator #1 reports "break" (F, top) and "recovery" (F, bottom). [Click to enlarge PowerPoint \(Microsoft Corporation, Redmond, Wash.\)](#). A slideshow presentation organizes the [VCE-associated album](#) of image and video exam data. The authors use PowerPoint to organize all potential exam components the students may request as it allows for image animations and video embedding. Each slide houses a specific exam procedure and/or result. Educator #1 operates the PowerPoint album, which is organized

in a logical sequence to aid in navigation and presents the necessary slides with Zoom’s screen-share function. The entire VCE is composed of images and videos of exam findings, presented only after students correctly instruct the patient and describe the equipment setup. The students view each requested test individually while the entire VCE album remains hidden. As educator #1 voices the patient’s response throughout a procedure, the corresponding image is presented (**Figure 2**). In many exam procedures the slide uses animations to present images sequentially according to patient responses, for instance, when reporting “blur” and “break” in vergence testing. Students are not given hard or digital copies of exam data. To mimic an actual clinical experience, the case images and videos are presented temporarily and the students are expected to record the interpreted data. Each group’s unique navigation through a VCE may result in unseen slides for the data that is not requested. A [complete case and the associated VCE album are provided here](#) for review and application to clinical education.

- Flipgrid ([Microsoft Corporation, Redmond, Wash.](#)). A video-hosting platform enables students to record their patient education at the conclusion of the VCE. Flipgrid is an online social engagement tool that uses video sharing to house educator-posed topics that collect learner-generated content in response. Flipgrid also allows peer feedback in video response. The authors use Flipgrid to host the students’ patient education videos. Flipgrid offers a customizable time limit for each video, which the educator controls. The authors use a 90-second time limit for the students to record their patient education, performed as if the patient is sitting in front of them. During the discussion session, the students’ patient education videos are viewed and evaluated for the key components of patient education, including but not limited to appropriate language, exhibited sensitivity, explanation of diagnosis, prognosis, use of educational materials, communication of management and treatment options and overall professionalism.
- Google Docs ([Google LLC, Mountain View, Calif.](#)). A shared online document allows students to compose their assessment and management at the conclusion of the VCE once the patient is dismissed. Google Docs is an online-based word processor that allows for real-time collaborative writing and editing. All users are able to see individual contributions and changes as they work towards a final document. The authors create Google Docs in advance, which are shared with the students in the videoconference chat during the first clinic session, taking precaution to prevent other student groups from viewing the document.

Case format

All exam findings are presented in images or videos, which can be easily acquired using cell phone cameras and readily available optometric equipment. Gracious colleagues or family members can pose as the patient in the necessary images and videos using basic equipment such as the occluder and the diagnostic kit. For fundus photos and more sophisticated ancillary testing, de-identified images from a clinical database may be utilized.

The VCE-associated case is composed by the educators, a collaborative effort with key points pulled from past clinical experience and in alignment with the didactic curriculum. Highlighting exam nuances that students find challenging due to low encounter frequency or higher level of required clinical reasoning may prove beneficial. Careful content development is required as the educators must predict the various avenues students may logically take to conduct the exam. An [album of clinical images and videos specific to the case](#) is compiled to accommodate requested testing within reason. Any illogical testing requested by the students may otherwise be deemed not relevant to the case, or students may be given a verbal account of the expected finding if needed. Realistic obstacles can be incorporated for the students to overcome, such as the need to use auxiliary cylinder lenses in the phoropter.

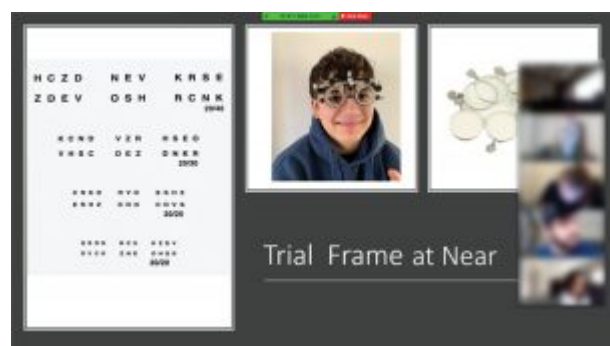


Figure 3. The VCE is conducted in Zoom using the screen-share function. A “gallery view” of five student participants is seen on the right as they trial frame the manifest refraction at near. The students ask about the patient’s visual comfort and check near acuity using the presented near card. Educator #1 uses the case script to respond and read the appropriate letters with planned

The educators determine the case details and patient responses prior to the VCE (Figure 1). Creating a script outlining the chief complaint, ocular, medical and family history, visual acuity, refractive status and pertinent exam findings is essential for case consistency and ease of response for educator #1. For instance, to assess visual acuity educator #1 (the patient) is instructed by a student to “cover your left eye and read the lowest line of letters you can see.” Educator #1 responds by reading the presented eye chart at the predetermined acuity level, including purposeful errors, allowing the students to determine the correct final acuity (**Figure 3**).

In the VCE no preliminary data is given. The encounter begins with a patient photo and his or her age. The students are not provided with an exam template, ensuring that data is not indiscriminately collected and encouraging them to use exam results to determine additional necessary tests. The VCE requires the students to be knowledgeable about efficient clinical practices, including eliciting case history,

errors, letting the students determine and record the correct acuity. [Click to enlarge](#)

properly instructing the patient, correctly interpreting test results and utilizing necessary ancillary testing. For example, a fundus image with a peripheral retinal hole should alert the student to request scleral depression and ask the patient about pertinent symptoms. To increase student clinician responsibility for the encounter, the students compose their formal assessment and management at the conclusion of the exam, including the final spectacle prescription, required follow-up and signing the virtual chart.

Discussion and review of the virtual clinical encounter

During the second clinic session, which is led by educator #2, the students re-experience the simulated exam in an open discourse with the educator, where level of efficiency, testing choices and pertinent concepts are addressed. The discussion is guided by the transcription-like record of the VCE, created by educator #2 during the prior session, along with the students' submitted assessment and management. Strengths, opportunities for improvement, weaknesses and any missed diagnoses from the VCE are discussed. Students exercise critical thinking as they are asked to support or retract inefficiencies and missteps. This somewhat informal discussion also allows the students to ask questions to their peers and preceptor regarding clinical judgement and individual practice styles.

After the conclusion of the exam discussion, the students' patient education videos are viewed by the group and educator using screen share in the videoconference application. Each student in turn states a positive characteristic and a potential area for improvement for each group member's video. Any key points not mentioned are highlighted by the educator. The students are then assigned to re-record their patient education in Flipgrid, applying the feedback received. Their peers later post additional feedback for each re-recorded patient education via video response in Flipgrid (Figure 1). In future VCE cases re-recordings can be assigned as needed.

Discussion

Using technology-enhanced distance learning, the VCE allows student clinicians to conduct a simulated comprehensive eye exam. When considering its educational impact using the SAMR model of technology integration, the VCE falls within the transformative areas of modification and redefinition due to the creation of an interactive virtual patient encounter experience that provides benefits beyond those available during in-person clinical encounters.¹⁵ This methodology allows the educators to witness the unfolding of the student-led exam, mimicking an observed student clinical encounter yet avoiding the student anxiety of direct observation by a preceptor in front of an actual patient. The educator gains an unparalleled view into the students' clinical judgement and an opportunity to enhance student clinical reasoning through detailed feedback and discussion. Unique advantages of this novel clinical education methodology include emphasis on clinical reasoning, purposeful content design, refinement of patient education skills, peer collaboration and comprehensive assessment in alignment with traditional clinical grading rubrics.

A common obstacle for professional students is the shift in mindset from simply collecting data to critically analyzing data to efficiently and successfully navigate an exam. Clinical reasoning is an acquired skill that can be learned in the context of a clinical encounter, real or simulated.¹⁸⁻²¹ The gap between students' translation of theory into clinical competency is likely a result of passive learning without sufficient application of critical thinking, which is required for successful clinical reasoning.¹⁸⁻²¹ The VCE creates learner-guided case history and test selection, preventing the students from relying on a preset exam template. Using a problem-based approach, the students must choose appropriate ancillary tests based on the evolving clinical findings throughout the encounter. This encourages students to exercise clinical reasoning throughout the VCE as they consider the case history and exam data to make the correct diagnoses.

Traditional learning cases are passive exercises when considering data collection. Cases presented in the Patient Assessment and Management (PAM) format of the National Board of Examiners in Optometry (NBEO) Part II exam prevent students from practicing ongoing analysis during data collection, but instead present all data necessary to establish the diagnoses and finalize treatment and management. Clinical reasoning in these exercises is limited to data analysis for diagnosis and appropriate treatment and management at the end of a reviewed case. In contrast, the VCE is designed for students to actively reason through case history, test selection, modification of exam techniques and data interpretation throughout the simulated exam in order to arrive at the appropriate diagnoses. If the students collect insufficient data during the VCE, the diagnoses may be incorrect or missed. The educator observes the students' clinical judgement during these processes to comprehensively assess their level of clinical competency and identify areas for improvement.

As opposed to the somewhat haphazard development of students' strengths according to the sequence of clinic patients and/or

specialties they are assigned to for their in-person training, a series of VCEs can be systematically designed at the appropriate level of knowledge base and corresponding clinical reasoning in parallel with the didactic curriculum. Utilizing incrementally advancing topics in VCE cases creates continuity of learning as the students draw from past discussions, allowing the educator to easily observe student growth over time. Subsequent VCEs show incorporation of prior discussions leading to increased efficiency, critical thinking and clinical reasoning. In the short course of VCE implementation thus far, weekly gradual improvement has been demonstrated by each student. Importantly, VCE cases may be further developed to expose students to low-frequency but high-criticality cases they may not encounter during their training. This includes conditions such as giant cell arteritis and acute angle closure, where proper management can be life and/or vision-saving. Exposing students to simulated patients with critical conditions improves their management skills, preventing errors when these emergent situations arise in clinical practice.^{7,8}

Adding a skills component to the VCE, each student records their patient education using a video-sharing platform. Incorporating social media into structured education often creates learner-generated content, promoting student engagement and active learning, which can also be monitored by the educator.²²⁻²⁴ The social media video-sharing tool Flipgrid provides a secure outlet for students to practice and refine their patient communication and education skills, a key aspect of successful optometric practice. This activity is used to examine the students' professionalism, level of sensitivity, appropriate use of language, description of management and treatment options and effectiveness of communication style, consistent with the evaluation metrics of the NBO Part III Clinical Skills exam. Patient communication skills, typically only refined over time during actual patient encounters, are arguably the foundation of the doctor-patient relationship and a key factor in positive patient outcomes.²⁵ The VCE creates a unique opportunity for students to develop these skills using a supervised simulated patient, rather than an actual patient.

The small group format of the VCE facilitates learner-guided collaboration. Students are able to share their strengths, learn from peers, engage in friendly debate and exhibit leadership as the group conducts the exam. Each student group's particular navigation through a VCE results in variations in the elicited case history, selected tests and final management decisions. The students may or may not collect the necessary data to determine the correct diagnoses by the end of the exam. For example, once the simulated patient is dilated, the students can no longer assess the patient's accommodative status when attempting to finalize the glasses prescription. While some errors are realized during the VCE, others are missed and need to be identified in the discussion session. The second clinic session is used to provide timely feedback in a structured discussion, which is important to the success of small group learning.²⁶ The educator's discussion is personalized to each student group, utilizing the transcription-like record created during the first clinic session to address individual strengths and opportunities for improvement.

Consistent with the VCE's intent, students apply procedural and didactic knowledge while practicing critical thinking and clinical reasoning throughout a simulated patient encounter. Thus, the VCE allows the educators to apply a traditional clinical grading rubric in distance learning, including evaluation of clinical skill, analysis, judgement, communication and professionalism. In a VCE students have an equal opportunity for success in their clinical evaluation using a common simulated patient, whereas in actual clinic individual patients influence student evaluations according to variable exam complexity. Additionally, the educator's transparent observation of student clinical competency more accurately reveals the student clinician's level of proficiency as the simulated exam unfolds. As the educator hears the students' thought processes, the causes of decreased efficiency such as unnecessary testing or gaps in knowledge are more easily identified. This thorough assessment of student clinician performance allows for detection of critical student errors that may go undetected in traditional clinic, such as poor endpoints in tonometry mire alignment, which are revealed and corrected in the subsequent discussion session (Figure 2).

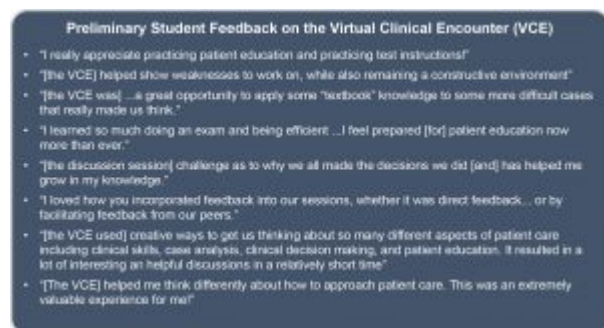


Figure 4. A sample of unsolicited positive student feedback on the VCE, which was received via written comments in end-of-quarter faculty evaluations and in direct e-mails to the

The lack of motor skills assessment, not feasible away from clinical equipment, is the greatest limitation to the described clinical education methodology. However, this allows for emphasis on development of critical thinking skills leading to stronger clinical reasoning, which is the more challenging skill to teach.¹⁸⁻²⁰ While the VCE requires careful content development, which may be time-consuming, the activity can be reused with new student groups and may be expanded into follow-up visits of the same simulated patient, building on the students' previously submitted assessment and management. Although the VCE is only modestly technologically sophisticated, this allows for adoption into any existing optometric curriculum with educators who are willing to learn the platforms used. Future enhancements in this methodology may include the use of simulated telemedicine for more realistic patient interaction.

An overall positive student attitude towards the VCE was captured in unsolicited student comments received in the authors' faculty evaluations and e-mail exchanges with students. The informal feedback showed student appreciation for the identified gaps in their knowledge, exercises in critical thinking, patient education skills practice and personalized group feedback (**Figure 4**). Although quantitative outcome measures are needed to validate this methodology, improved student performance was readily observed after only a few VCE and discussion sessions.

Conclusions

The VCE transforms the traditional clinical education experience into a controlled clinical learning environment using a novel distance learning methodology with simulated patients. The VCE provides opportunities to improve student clinical performance beyond those available using traditional case analysis and in-person precepted clinical encounters. Due to the educator created content and detailed feedback, this methodology helps to close the gap between theory and clinical competency. The VCE promotes improved clinician efficiency, knowledge base, critical thinking and enhances clinical reasoning. Additionally, the video-sharing component enhances patient education skills using learner-generated content and individualized feedback from educators and peers.

The VCE has been well-received by students with obvious overall improvement in clinical performance noticed by both educators and student clinicians. While born out of necessity to continue clinical education during social distancing, long-term the VCE may serve as a preparatory activity for clinic, adjunct to clinical education, elective clinical education course, patient education training activity, and/or facilitate clinical remediation.

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Disclosure

The authors declare they have no financial interest in any of the companies mentioned in this paper to disclose.

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Ocular Complications of Confirmed COVID-19 in a Systemically Asymptomatic Patient Using Telehealth: a Teaching Case Report and the Optometrist's Role in Culturally Competent Public Health

Jeanie C. Lucy, OD, MPH, FAAO | Optometric Education: Volume 46 Number 1 (Fall 2020)

Background

Follicular conjunctivitis presents as a local host response to an exogenous substance or agent producing prominent subconjunctival lymphoid follicles. Viruses, chlamydia and other bacteria can produce the problem.¹ New cases of coronavirus disease 2019 (COVID-19) have escalated around the world. As local, state and national governments take extraordinary measures to limit its spread, uncertainty remains regarding how this virus may present in each organ system. There is known damage to the respiratory system, causing edematous mucous membranes, damaged alveoli, scar tissue, impaired oxygen flow and acute respiratory distress syndrome.¹ Experts have reported that organs other than the lungs can be affected by the virus, but data regarding ocular manifestations is limited.² Careful history, clinical examination and lab tests are required to diagnose COVID-19. This teaching case report is significant in that it highlights one of only a few reported ocular findings associated with COVID-19. It is intended for third- and fourth-year optometry students and all eyecare providers in clinical care.

Case Description

A 48-year-old Hispanic male presented to a local hospital on April 27, 2020, with complaints of watery eyes, sensitivity to light and mild eye pain. He also reported his wife had been experiencing chest pain and breathing problems for two days. She was immediately referred to the emergency department and she tested positive for COVID-19. The patient had no systemic symptoms, but he also was administered a nasopharyngeal swab test for COVID-19, which returned positive. He reported being a construction worker and disclosed no known history of exposure to others with COVID-19. His wife was a stay-at-home mom. He was sent home with the recommendation to quarantine for two weeks unless additional problems occurred.

The patient returned to urgent care two days later, on April 29, 2020, reporting chronic eye irritation. He tested positive a second time for COVID-19. His temperature was 98.6 degrees Fahrenheit, and physical examination showed normal findings except for tender pre-auricular lymph nodes on both sides. The patient's height was 5 ft. 11 in. and his weight was 170 pounds. His blood pressure was 115/78 mmHg. The primary care physician documented risk stratification as low based on respiratory rate, negative hypoxia, no change in mental state and no signs of being critically ill. Serology testing was ordered to determine whether the patient had antibodies for COVID-19 or false-positive previous test results. Additional blood work was ordered to access D-dimer, ferritin and C-reactive protein (CRP) levels.

The patient was referred to primary care optometry the same day and examined via telehealth with the assistance of medical technology services using personal protective equipment. On admission to the eye service, a COVID-19 case history protocol was followed. History of present illness included foreign body sensation and watering in both eyes. The patient denied having similar eye problems in the past. He reported that he was not experiencing ocular burning, itching, flashes, floaters or fluctuations in vision. He stated he had not been rubbing or touching his eyes with his hands. His last comprehensive well care examination was five months prior. Periorbital pain scale evaluation was 4/10 for both eyes.

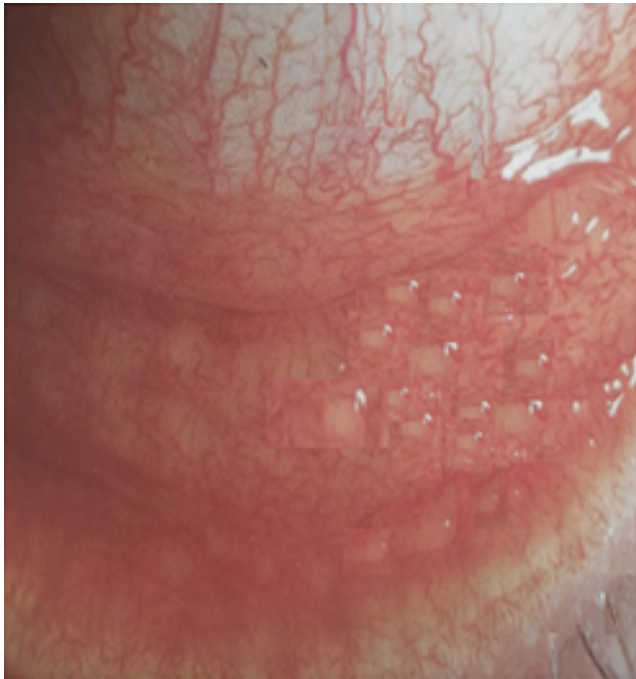


Figure 1. When the patient was admitted to the eye service, slit lamp examination revealed follicular conjunctivitis in the inferior fornix of both eyes (right eye shown). [Click to enlarge](#)

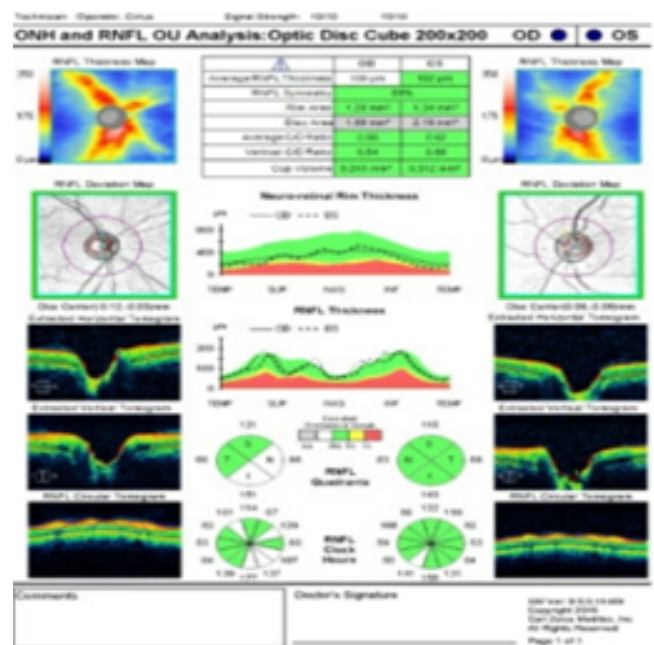


Figure 2. When the patient was admitted to the eye service, OCT showed no thinning of the retinal nerve fiber layer in either eye. [Click to enlarge](#)

Visual acuities were measured as 20/20 OD, 20/20 OS at distance and 20/30 OD, 20/30 OS at near without correction. Slit lamp examination revealed notable inferior conjunctival follicles in both eyes (**Figure 1**). Lids, lashes, cornea and anterior chamber were all unremarkable. There was watery discharge OD and OS. No mucopurulent discharge, injection or scarring was noted. Intraocular pressures, measured at 9 a.m. with iCare tonometry, were 14 mmHg OD and 11 mmHg OS. Conjunctival reverse transcription polymerase chain reaction (RT-PCR) testing for COVID-19 was performed (sterile swab, each fornix, without anesthesia).

Dilated fundus examination showed cup-to-disc ratios of 0.6 OD and 0.6 OS. Optical coherence tomography (OCT) scans (Zeiss Cirrus, optic disc cube 200x200) of both eyes, with reliable signal strengths, showed retinal nerve fiber layer thickness within normal limits (**Figure 2**). Fundus photographs (Zeiss Clarus 500 v1.0) were unremarkable with no signs of thrombosis OD or OS (**Figure 3**). The patient was instructed to use artificial tears four times per day and warm compresses three to four times per day. He was scheduled for a follow-up visit in two weeks and released to continue self-quarantine.

Two weeks later, on May 13, 2020, the patient participated in a telehealth home visit and reported intermittent relief. He was informed that the previously performed fornix swab testing was positive for COVID-19, consistent with his serological test results, which showed positive antibodies for the virus. Results of the other previously performed blood tests showed D-dimer, ferritin and CRP within normal ranges. Positive tests were reported to the department of public health. Exam findings were consistent with findings two weeks prior except the patient reported photophobia on this particular day. Supportive treatment was continued.

Two weeks later, on May 27, 2020, during a home telehealth phone consultation, the patient reported he had been free of all ocular symptoms for the past 24 hours. With asymptomatic systemic COVID-19 infection, he continued home isolation and monitoring and the recommended ocular support care for another two weeks. Three other members of the household — two teenage children and the patient's mother-in-law — had tested positive for COVID-19 via nasopharyngeal swab tests over a period of four weeks. The teenagers' only symptoms

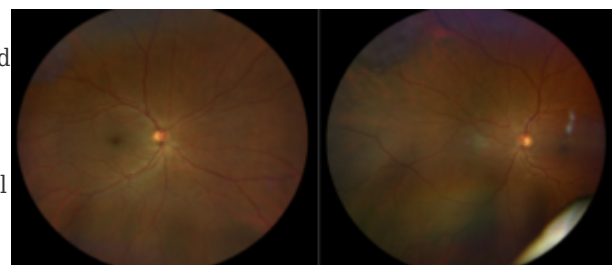


Figure 3. Initial fundus photographs of each eye. Dilated fundus exam showed cup-to-disc ratios of 0.6 OD and 0.6 OS and no specific areas of concern. [Click to enlarge](#)

were loss of taste and sense of smell. The patient's mother-in-law was hospitalized due to breathing problems and chest pain. All members of the family recovered (**Figure 4**).

Education Guidelines

Key concepts

1. Follicular conjunctivitis has a viral component; therefore, differential diagnoses should include COVID-19. This may help eyecare providers in recognizing COVID-19
2. A multispecialty medical team, which includes eyecare professionals, is an essential standard of care for optimal patient outcomes
3. When cases of COVID-19 are diagnosed in eyecare practice, public health reporting systems are a key component of completing the public health triad of test, treat and trace
4. Telehealth is a useful component of patient care in optometric practice and may help with cultural understanding and communication and effectively increase interaction with patients across cultures, especially those with disparities in eye health

Learning objectives

At the conclusion of this case discussion, participants should be able to:

1. Understand both the current definition of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) as well as the disease name COVID-19 as outlined by the International Committee on Taxonomy of Viruses (ICTV)
2. Develop a case history protocol for diagnosing COVID-19 patients under investigation (PUI) who are symptomatic or asymptomatic in eyecare practice
3. Recognize systemic and ocular findings associated with COVID-19 including follicular conjunctivitis
4. Understand ocular tests, lab tests and ancillary tests and how they can be used to diagnose and manage COVID-19 patients
5. Understand public health reporting and the triad of test, treat and trace to mitigate disease spread
6. Provide culturally competent patient education including co-management with other specialists, using telehealth when necessary

Discussion points

1. Knowledge and concepts required for critical review of the case:
 - a. What virus name, virus classification and disease name have been specified for COVID-19?
 - b. What pertinent questions should be included in the case history protocol for COVID-19 PUI to improve clinical decision-making and identification of risk factors?
 - c. What organ systems are known to be affected by COVID-19?
 - d. What are the current known ocular manifestations of COVID-19?
2. Differential diagnosis:
 - a. What are the differential diagnoses of follicular conjunctivitis?
 - b. What is the purpose of test, treat and trace for COVID-19?
 - c. How is reporting done for confirmed cases of COVID-19?
 - d. What tests are available for systemic and ocular complications of COVID-19?
3. Disease management:
 - a. How would you manage follicular conjunctivitis as an ocular complication of COVID-19?



Figure 4. Timeline of patient's COVID-19 exposure, quarantine, positive test results and ocular symptoms.
[Click to enlarge](#)

b. How would you utilize a multispecialty team to treat a COVID-19 patient?

c. Describe the role of telehealth in the management of COVID-19 patients

4. Patient education:

a. What role does cultural competence play in COVID-19?

b. How would you educate the patient regarding this diagnosis?

c. What other important outcomes should be discussed?

5. Critical thinking:

a. What personal protective equipment is needed to examine PUI for COVID-19?

b. How can digital tools be used in contact tracing for confirmed cases of coronavirus?

c. What role does quarantine play in this case?

Discussion

Coronaviruses are not new pathogens. They were first isolated from chickens in 1937. Human coronaviruses were identified in the mid-1960s.³ On Dec. 31, 2019, the World Health Organization (WHO) China Country Office was notified about several cases of pneumonia of unknown etiology in Wuhan City, China. Immediately following, China's National Health Commission reported that the outbreak had been traced to a seafood market in Wuhan. Later, metagenomic next-generation sequencing technology was used to identify a novel coronavirus in a bronchoalveolar lavage fluid sample from the Wuhan Seafood Market.^{3,4} Scientific authorities isolated and identified this novel coronavirus and shared its genetic sequence on Jan. 12, 2020.⁴

Coronaviruses belong to the *Coronaviridae* family of viruses. All viruses are named based on their genetic structure to facilitate the development of diagnostic tests, vaccines and medicines. Virologists and the wider scientific community name viruses according to standards set by the ICTV. The ICTV announced SARS-CoV-2 as the name of the newly discovered virus on Feb. 11, 2020. This name was chosen because the virus is genetically related to the coronavirus responsible for the SARS outbreak of 2003. While related, the two viruses are different. Also on Feb. 11, 2020, WHO announced COVID-19 as the name of the disease caused by SARS-CoV-2.⁴ Members of the *Coronaviridae* family are enveloped, positive-sense, single-stranded RNA viruses.

The phylogenetic analysis of coronaviruses classifies them into four genera: α , β , γ , and δ . The coronaviruses of the α and β genera generally infect mammals and humans, while the coronaviruses of the γ and δ genera mainly infect birds. SARS-CoV-2 is a novel coronavirus of the β genus. It is round or oval with a diameter of 60-140 nm and a crown-shaped appearance under electron microscopy.⁵ Seven types of coronaviruses are known to infect humans: 229E (*alphacoronavirus*), NL63 (*alphacoronavirus*), OC43 (*betacoronavirus*), HKU1 (*betacoronavirus*), MERS-CoV (*betacoronavirus*), SARS-CoV (*betacoronavirus*), and the most recent SARS-CoV-2.⁵ It is widely agreed that these viruses cause respiratory tract infections, and patients can present with a wide spectrum of manifestations. A protein sequence analysis showed that the amino acid similarity of the seven conserved nonstructural proteins between SARS-CoV-2 and SARS-CoV was 94.6%, suggesting that they might belong to the same species. The homology between the SARS-CoV-2 genome and the bat SARS-like coronavirus [Bat-CoV (RaTG13)] genome is 96%.⁶

In addition to causing human respiratory tract infection, coronaviruses can cause animal intestinal infection. The process of infection requires the participation of receptors on the surface of the host cell membrane. The S protein on the surface of coronaviruses can recognize and bind to the receptor and then invade the host cell through clathrin-mediated endocytosis.^{7,8} Different coronaviruses can use different cell receptors to complete the invasion. The severe immune injury COVID-19 can cause has been attributed at least partially to the overactivation of T cells (manifested by an increase in Th17 cells), which play a role in defense against extracellular pathogens by mediating the recruitment of neutrophils and macrophages, coupled with high cytotoxicity of CD8 T cells.⁹

One study revealed that SARS viral detection peaks at two weeks. The incubation period is 1-14 days with an average of 3-7 days. The main routes of transmission are respiratory droplets and articles contaminated with virus droplets. Asymptomatic patients may also be a source of infection.⁹ Another study showed that SARS-CoV-2 nucleic acid can be detected in the feces and urine of patients with COVID-19, suggesting that the virus may be transmitted via the fecal-oral route.

The main symptoms of COVID-19 caused by SARS-CoV-2 are fever (87.9%), dry cough (67.7%), fatigue (38.1%), sputum production (33.4%), shortness of breath (18.6%), sore throat (13.9%), headache (13.6%), myalgia or arthralgia (14.8%), chills (11.4%), nausea or vomiting (5.0%), nasal congestion (4.8%), diarrhea (3.7%), hemoptysis (0.9%) and conjunctivitis or conjunctival congestion (0.8%).¹⁰

Serious cases of COVID-19 may progress rapidly to acute respiratory distress syndrome, coagulation dysfunction and septic shock.¹³⁻¹⁶ Mild cases tend to involve low fever and slight fatigue but no pneumonia. Most patients have a good prognosis, but some have severe morbidity and higher mortality. Risk factors for higher mortality include asthma, cerebrovascular disease, cystic fibrosis, hypertension, HIV, dementia, liver disease, pregnancy, pulmonary fibrosis, smoking, thalassemia, history of blood clots, type I diabetes and advanced age.¹¹⁻¹⁴

Also of concern is the presence of the virus in ocular tissue. In 2004, tear samples collected from 36 suspected SARS-CoV patients were sent for RT-PCR testing. The SARS-CoV RNA was identified in three of the patients. Out of the three, one patient had the RNA identified not only in tear samples but also in stool samples and respiratory swab samples. One patient had RNA identified in stool and tear samples, but the respiratory swab was not sent. The third patient had RNA identified in tear samples only while stool samples were negative, and the respiratory swab was not sent. The findings of this study suggested that SARS-CoV can be present in tears and emphasized the need for appropriate precautions to prevent transmission through ocular tissues and secretions.¹⁵ As of this writing, it remains unclear how SARS-CoV can end up in tears. Theories include that the conjunctiva is the direct inoculation site of SARS-CoV from infected droplets, the upper respiratory tract infection migrates through the nasolacrimal duct, or viral infection of the lacrimal gland is hematogenous.¹⁶ In this case report, acute viral follicular conjunctivitis was the clinical presentation. Swab testing confirmed COVID-19. While COVID-19 has been documented in the tears, ocular complications of SARS-CoV2 follicular eye disease is still not fully understood especially in terms of possible transmission.

Differential diagnosis

There are a multitude of ocular conditions that present with follicular conjunctivitis. The follicles appear as gray-white, round-to-oval elevations measuring 0.5-1.5 mm in diameter. From an epidemiological perspective, ocular follicular conjunctivitis caused by viruses accounts for up to 80% of all cases of acute conjunctivitis.¹⁷ The rate of clinical accuracy in diagnosing viral conjunctivitis is less than 50% compared with laboratory confirmation.¹⁷ Many cases are misdiagnosed as bacterial conjunctivitis.¹⁷ Between 65% and 90% of cases of viral conjunctivitis are caused by adenoviruses,¹⁷ and they produce two of the common clinical entities associated with viral conjunctivitis, pharyngoconjunctival fever and epidemic keratoconjunctivitis.¹⁷

Follicular conjunctivitis may present as an acute or chronic disease. Acute cases are commonly associated with viral ocular disease (epidemic keratoconjunctivitis, herpes zoster keratoconjunctivitis, infectious mononucleosis, Epstein-Barr virus infection) or chlamydial infections (inclusion conjunctivitis). Chronic follicular ocular disease may be caused by chronic chlamydial infection (trachoma, lymphogranuloma venereum) or as a toxic or reactive inflammatory response to topical medications and molluscum contagiosum infection. Secondly, symptoms of hyperemia, chemosis, watery discharge, photophobia and periorbital pain are associated signs of viral conjunctivitis. Based on extensive patient history, COVID-19 should be added to the list of differential diagnoses for patients presenting with follicular viral conjunctivitis. Treatment should be based on ocular signs and symptoms as well as any systemic disease.¹⁸

Role of case history protocol

Standard case history plus additional historical data are important during an outbreak or epidemic even in low prevalence areas as predictive values may change. One tool for collecting the relevant information is the *Human Infection with 2019 Novel Coronavirus Case Report Form*.¹⁹ This COVID-19 questionnaire includes exposure query regarding domestic and international travel, cruises, family gatherings, workplace gatherings, adult congregate living facilities (nursing, assisted-living or long-term care facilities), school gatherings, correctional facility visits, community events, healthcare worker exposure or exposure to persons known to have COVID-19. Based on symptoms and case history, the triad of test, treat and trace is the standard of care that should be initiated.

COVID-19 testing

Currently, follicular conjunctivitis is the most reported ocular manifestation of COVID-19. However, given the higher number of thrombotic episodes reported in the literature for COVID-19, it is also considered a prothrombotic disease.²⁰ Thorough ocular posterior segment examination with the aid of OCT and fundus photos is beneficial in ocular thrombotic evaluation. The COVID-19 RT-PCR test is a real-time test for the qualitative detection of nucleic acid from SARS-CoV-2 in upper and lower respiratory specimens (such as nasal, nasopharyngeal or oropharyngeal swabs, sputum, lower respiratory tract aspirates,

bronchoalveolar lavage, and nasopharyngeal wash/aspirate or nasal aspirate) collected from individuals suspected of infection with COVID-19 by their healthcare provider. Individuals may also self-collect nasal swab specimens for this test at home when a healthcare provider deems it appropriate based on results of a COVID-19 questionnaire.

Viral loads are high at symptom onset with a viral detection peak at two weeks after onset. Blood/serology testing for COVID-19 is also available, but blood tests are not intended for diagnosis of recent or active disease. Testing of this nature is useful for confirming prior infection by detection of an immune response to COVID-19 in individuals who are at least 14 days post-symptom onset or following exposure to individuals with confirmed COVID-19. Some studies have shown that blood tests revealing higher levels of D-dimer, ferritin and CRP indicate more severe disease.^{21,22,23} Follow-up with local and state departments of public health for confirmed positive results is required.

COVID-19 treatment and prevention

At the time of this writing, no vaccine or treatment specific to COVID-19 is available. Most people who become ill with COVID-19 recover at home. Treatment for severe cases is aimed at mitigating symptoms. On March 24, 2020, the U.S. Food and Drug Administration (FDA) began allowing convalescent plasma to be used in patients with serious or immediately life-threatening COVID-19 infections.²⁴ This treatment is still considered experimental. Convalescent plasma has been used for years, with intermittent success. Currently not much is known about its effectiveness for COVID-19. There have been reports of success from China, but no randomized, controlled studies have been done. Experts also have not determined the best time during the course of the illness to administer convalescent plasma. A recent report by the Center for Evidence Based Medicine cited a clinical trial that showed the corticosteroid dexamethasone decreased the risk of dying in extremely ill hospitalized COVID-19 patients. The report was released prior to publication of the study indicating that the research results have not gone through peer review. Early reports from China and France suggested that patients with severe symptoms of COVID-19 improved more quickly when given chloroquine or hydroxychloroquine. Some doctors were using a combination of hydroxychloroquine and azithromycin with some positive effects, but evidence-based clinical trials have yet to support this.²⁵

Remdesivir, an investigational nucleotide analog with antiviral activity, was compared with placebo in more than 1,000 people hospitalized with COVID-19. In this analysis, patients who received remdesivir recovered more quickly than those who received placebo (a median of 11 days for remdesivir vs. a median of 15 days for placebo).²⁶ The difference was statistically significant. Remdesivir was less effective in sicker COVID-19 patients, including those on a ventilator or on a heart-lung machine. In early May 2020, the FDA issued an emergency use authorization for remdesivir in adults and children hospitalized with severe COVID-19 illness.²³ Finally, vitamins C and D may protect against COVID-19.²⁶ Vitamin D may help boost the body's natural defense against viruses and bacteria. Second, it may help prevent an exaggerated inflammatory response, which has been shown to contribute to severe illness in some people with COVID-19.²⁷ The idea that high-dose IV vitamin C might help in overwhelming infections is not new. A 2017 study by Marik et.al. found that high-dose IV vitamin C treatment (along with thiamine and corticosteroids) appeared to prevent deaths among people with sepsis, a form of overwhelming infection causing dangerously low blood pressure and organ failure, which has been seen in COVID-19 patients.^{28,29}

Treatment for the relatively newly discovered ocular complications of COVID-19 is also aimed at mitigating symptoms. Follicular conjunctivitis is typically self-limiting. Treatment targets the underlying condition and includes support therapy such as artificial tears. Doctors in China treated follicular conjunctivitis in a patient with severe systemic COVID-19 with ribavirin eye drops, which gradually improved the patient's symptoms.³⁰ As in all cases of viral conjunctivitis, patients should discontinue contact lenses wear and use spectacles if needed. In cases of disease or non-disease, non-pharmaceutical interventions are highly effective in mitigating the spread of COVID-19 and include social distancing, wearing face masks in public, and frequent hand-washing. These measures hold promise for ocular prevention as well.

Cultural competence in public health optometry

Evidence-based research supports collaborative multispecialty medicine for better patient outcomes.³¹ Pandemics often provide opportunity for healthcare professionals at every level to elevate multidisciplinary approaches to mitigate disease. In the most severe cases of COVID-19, patients are hospitalized. Given that symptoms may range from zero to life-threatening, optometrists are in a unique position to identify and treat ocular symptoms and refer as needed. When COVID-19 is suspected based on exposure and symptoms, telemedicine is an appropriate integrative choice for improving public health. From telephone calls to apps, telehealth has been widely used in the current climate. Patient education is a key factor for helping to prevent spread of the virus when disease is found.

The concept of cultural competency is broad and used to describe a multitude of interventions that aim to improve access and effectiveness of healthcare services for all minority groups.³² Minorities have been affected by COVID-19 at alarmingly higher rates, and awareness is key to mitigation.³³ This teaching case report illustrates two important aspects of cultural competence,

increased access and communication, as positive interventions in public health practice.

Assessment of Learning Objectives

1. Students can be tested on the definition and ICTV name of COVID-19 and how the current definition applies clinically to the ocular complications of systemic disease including follicular conjunctivitis
2. Students presented with a routine or urgent ocular case can be evaluated on the development of a more comprehensive historical account of the case, which can be accomplished using a series of questions based on the Centers for Disease Control and Prevention's *Human Infection with 2019 Novel Coronavirus Case Report Form*.¹⁹
3. Based on PowerPoint slide quizzes, students should be able to develop a differential diagnosis for all follicular conjunctivitis diseases, which includes how to rule out bacterial vs. viral and acute vs. chronic follicular conjunctivitis as well as current potential systemic findings associated with COVID-19.
4. Students should be evaluated on their knowledge of the lab tests available for detecting active systemic COVID-19 infection, previous exposure to the virus, and SARS-CoV-2 in the eye and how to use them
5. To foster continuity of care, a list of co-managing physicians, hospital referral contacts and telehealth options could be written up as an information brochure for low- to no-symptom patients suspected of having COVID-19
6. Clinical-thinking skills regarding education for PUI for COVID-19 and protocols for testing, treating, and tracing can be practiced in small groups

Conclusion

Optometrists play an important role in public health surveillance and diagnosing and managing ocular complications of COVID-19. Outbreaks, especially of novel pathogens, create a pressing need to collect data on diagnostics and treatment and organ systems, including ocular clinical characterization, to inform rapid public health response. Optometrists' can increase cultural competence with awareness of healthcare disparities and by improving access and providing caring communication related to COVID-19.

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Acute Retinal Necrosis and Saving Vision in Aggressive Disease: a Teaching Case Report

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Background

This teaching case report covers the clinical manifestations of acute posterior segment infection from the herpes virus family with a focus on acute retinal necrosis (ARN). ARN is a rapidly progressive and potentially devastating viral infection of the retina that primarily presents in young, healthy individuals in the second to sixth decade with no predilection for race or sex.^{1,2} The etiology of this rare viral infection is associated with varicella zoster virus (VZV), herpes simplex virus type 1 (HSV-1), and herpes simplex virus type 2 (HSV-2).³ This report involves a 35-year-old healthy Hispanic male with sudden onset of ARN and a subsequent retinal detachment. The intention is to discuss how to recognize the disease, initiate treatment and co-manage these cases in an interdisciplinary setting. Acute retinal infections put patients at risk for further complications and vision loss if not treated early and aggressively with topical, oral and intravenous therapies. Thus, prompt and accurate diagnosis and treatment with interdisciplinary co-management are warranted. This case report is intended for third- and fourth-year optometry students, optometry residents and practicing doctors in a primary-care or urgent-care setting.

Case Description

A 35-year-old Hispanic male presented to the emergency room late at night and reported hazy vision that he described as a “plastic curtain” over his right eye. He also reported a red, painful (6 out of 10) right eye, and an associated headache on the right side. The patient had no significant medical or ocular history and was not taking any systemic or topical medications. He had no significant family medical or ocular history.

His entering unaided visual acuities were 20/20 OD and OS. His intraocular pressures (IOPs) were 37 mmHg OD and 12 mmHg OS with Goldmann tonometry. In the right eye, the cornea had fine keratic precipitates, and the anterior chamber had a reaction of 2+ cells. Ishihara color test was normal OD and OS. The anterior segment of the left eye was unremarkable. Dilated fundus exam revealed a trace vitritis and normal posterior pole and peripheral findings in the right eye. The posterior pole and periphery of the left eye were unremarkable.

The elevated IOP in the right eye was lowered in-office with instillation of one drop of each of the following medications: brimonidine tartrate 0.2% ophthalmic solution, dorzolamide hydrochloride 2% ophthalmic solution, timolol maleate 0.5% ophthalmic solution, and bimatoprost 0.03% ophthalmic solution. The drops lowered the pressure to 25 mmHg OD.

The patient was diagnosed with unilateral acute severe anterior uveitis OD with suspicion of a viral etiology with a secondary elevated IOP. The recommended treatment at this visit included three medications for the right eye: one drop of prednisolone acetate 1% ophthalmic suspension four times a day (QID), one drop of cyclopentolate hydrochloride 1% ophthalmic solution twice a day (BID), and one drop of timolol maleate 0.5% ophthalmic solution BID. To determine the etiology, the patient was encouraged to have blood tests. At this visit, the following tests were administered: human immunodeficiency virus (HIV), HSV-1, HSV-2, VZV, cytomegalovirus (CMV), rapid plasma reagin/venereal disease research laboratory (RPR/VDRL), antinuclear antibodies (ANA), purified protein derivative (PPD), angiotensin converting enzyme (ACE) and Lyme disease. The patient was instructed to return in the morning for follow-up during normal clinic hours.

Same-day follow-up

The patient returned that same day in the morning for follow-up. He reported good compliance with the prescribed topical medication treatment, but no improvement in symptoms since the night before. His entering unaided visual acuities were 20/20 OD and OS. His IOPs were 12 mmHg OD and 15 mmHg OS with Goldmann tonometry. In the right eye, there was a noted worsening of the vitritis; however, the posterior segment was normal with no significant findings. In the left eye, the anterior and posterior assessment remained unchanged with no significant findings. The patient was instructed to return in two days for an evaluation with the retina specialist.

Subsequent visits

At the two-day follow-up visit, the patient was seen in conjunction with a retina specialist. The patient reported good compliance with all prescribed topical medications but no improvement in symptoms in the right eye. The exam showed a

slight reduction in visual acuity from 20/20 to 20/25-2 in the right eye. White, necrotic lesions with multiple foci in the temporal periphery of the right eye, not noted in previous exams, were present. All exam findings remained normal in the left eye. Fundus photography (**Figure 1**) and fluorescein angiography (**Figure 2**) of the right eye were performed at this visit.

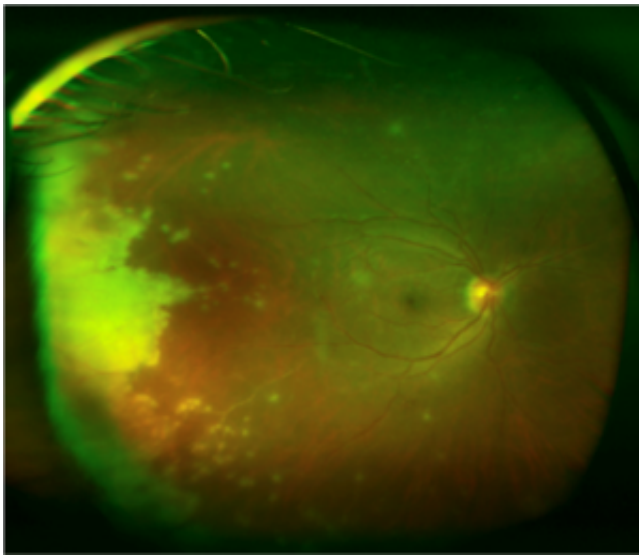


Figure 1. An ultra-widefield fundus photograph of the right eye on the third day after onset of symptoms shows temporal retinal necrosis. [Click to enlarge](#)

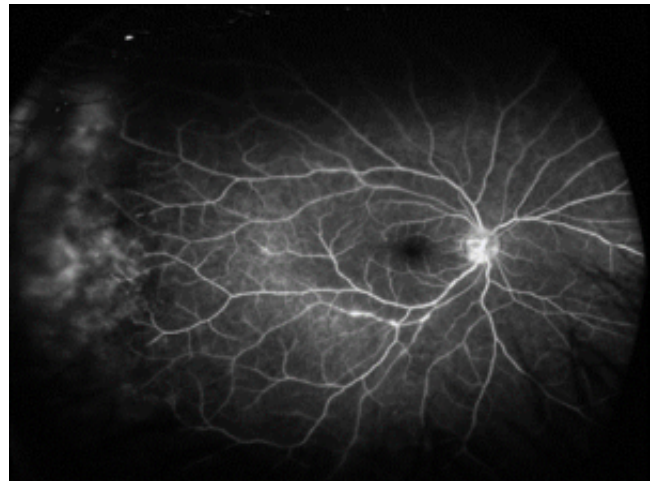


Figure 2. Fluorescein angiography of the right eye on the third day after onset of symptoms. [Click to enlarge](#)

Also during this follow-up visit, the patient's laboratory test results were obtained. They were positive for HSV-2 and CMV, and negative for HIV and all other potential etiologies. The nature of the disease was determined to be viral, and the patient was diagnosed with ARN in the right eye. He was prescribed valaciclovir 1g PO three times a day (TID) for 10 days. He also was instructed to continue all topical medications as prescribed at his previous visit.

The patient was closely monitored in the retina clinic and scheduled to return for follow-up every other day until completion of the antiviral therapy. Co-management with infectious disease specialists was initiated as the necrosis continued to progress and peripheral vascular occlusion and sclerosis developed in the right eye.

One week after onset of symptoms (Day 7), there was noted necrotic progression in the retina in the right eye and further worsening of visual acuity in the right eye to 20/100. Thus, based on a collaborative consult between the retina and infectious disease specialists, the oral antiviral therapy was deemed insufficient and the patient was admitted for treatment with intravenous (IV) ganciclovir and instructed to return for daily monitoring in the retina clinic as an in-patient. Five days after admission (Day 12), while the patient was receiving IV ganciclovir, the peripheral necrosis in the right eye developed into a temporal serous retinal detachment. Due to the noted progression of the retinal detachment towards the posterior pole (**Figure 3**), the patient was treated with an intravitreal injection of ganciclovir (Day 13).

Despite IV and intravitreal intervention, the retinal detachment continued to progress (Day 15). Thus, the next day (Day 16) the patient underwent an urgent pars plana vitrectomy (PPV) with silicone oil fill to prevent further detachment. After the surgery, the patient was under close daily monitoring by the retina specialist. Once the vision stabilized and the necrosis receded (**Figure 4**), the patient was discharged from the hospital.

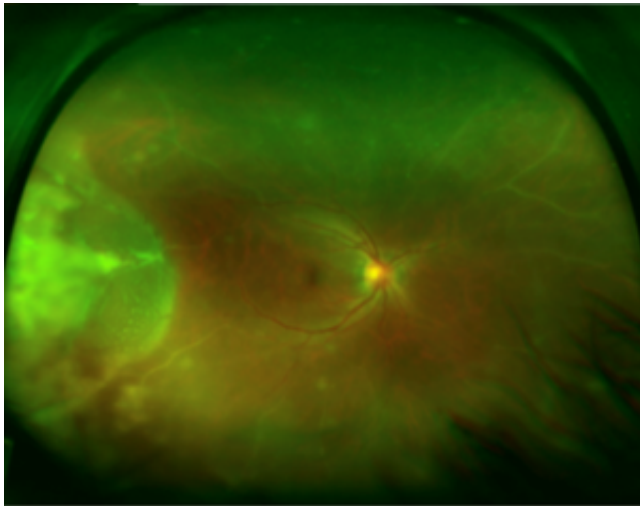


Figure 3. An ultra-widefield fundus photograph of the right eye on the 13th day after onset of symptoms shows a temporal serous retinal detachment. [Click to enlarge](#)

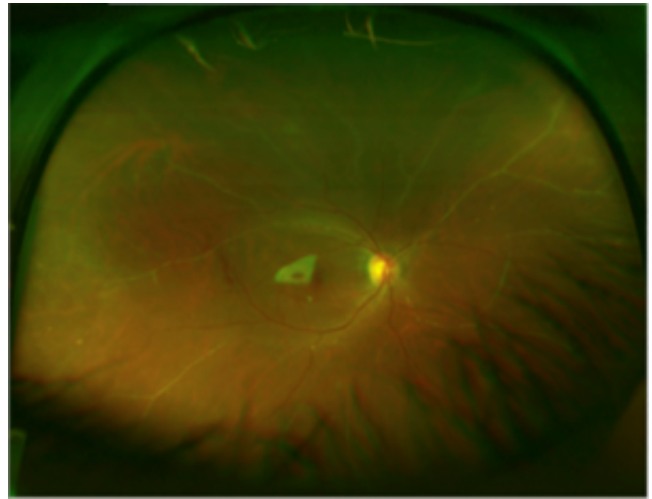


Figure 4. Ultra-widefield fundus photograph of the right eye captured one month after pars plana vitrectomy and silicone oil fill. (The imaging artifact at the macula is likely a reflection from the silicone oil.) [Click to enlarge](#)

The patient was advised to continue follow-up visits with the retina specialist as topical prednisolone acetate 1% ophthalmic suspension in the right eye was tapered (from QID, TID, BID, then QD - with each taper period lasting two weeks). He was also instructed to follow-up with the infectious disease specialists to complete an oral maintenance dose of valganciclovir. As of his last visit, the patient's visual acuity in the right eye had recovered to 20/25 with a -6.00D lens.

Education Guidelines

Learning objectives

1. Recognize signs and symptoms of ARN
2. Discuss differential diagnoses of anterior, posterior and hypertensive uveitis
3. Review indicated laboratory tests to confirm diagnosis
4. Review how to initiate appropriate treatment
5. Understand the role of the optometrist in an interdisciplinary setting

Key concepts

1. Differentials for anterior, posterior and hypertensive uveitis
2. Pathophysiology of acute retinal necrosis and its subsequent clinical complications
3. The importance of accurate and early treatment for best visual prognosis
4. The role of laboratory testing in determining etiology of infection and treatment plan
5. The importance of interdisciplinary co-management to address all treatment options and to optimize the visual outcome
6. The importance of close monitoring for disease progression

Discussion points and questions

1. Knowledge, concepts, facts and information for case review:
 - a. Describe the signs and symptoms of ARN vs. other causes of posterior uveitis
 - b. Discuss the epidemiology of ARN
 - c. Discuss the laboratory work-up that aids in diagnosis of ARN
 - d. Discuss the natural history and course of disease
 - e. Discuss the treatments available and efficacy of antiviral agents
2. Generating questions, hypothesis and diagnosis:
 - a. What diagnostic/lab tests were used to determine the final diagnosis?
 - b. How were the clinical findings used to rule out other differentials?

- c. What are the official criteria that need to be met to establish a diagnosis of ARN?
- d. If a patient presents with ARN, what associated systemic conditions should the patient be tested for?

3. Management:

- a. What are the different types of antiviral medications and how are they ranked in terms of efficacy?
- b. Why are steroids needed? What precautions should be taken when using steroids, oral and topical?
- c. Why are IOP-lowering drops needed?
- d. What course of action is needed should the symptoms regress with treatment?

4. Patient management and ethics:

- a. What are the consequences of patient non-compliance with treatment?
- b. What are some important points to discuss during patient education regarding the patient's disease progression and visual prognosis?

Discussion: Literature Review of ARN

Epidemiology and pathophysiology

The American Uveitis Society⁴ defines ARN by the following set of clinical manifestations:

- a. one or more foci of retinal necrosis with discrete borders located in the peripheral retina
- b. rapid progression in the absence of antiviral therapy
- c. circumferential spread
- d. evidence of occlusive vasculopathy with arterial involvement
- e. a prominent inflammatory reaction in the vitreous and anterior chamber

Though specific requirements need to be met to classify ARN, it can present in a range of severity and visual prognosis.⁵

ARN is a unique and rare ocular manifestation of a viral infection that is usually seen in healthy and immune-competent individuals, though some studies have suggested expanding the diagnosis of ARN to immune-compromised patients as well.¹ The presentation is usually unilateral, but can become bilateral in 9-33% of cases.^{1,2} Bilateral spread of ARN can occur from either the local (non-synaptic) transfer of the virus crossing at the optic chiasm, or from passing (trans-synaptic) through the neurons along the visual pathway.³

The incidence of ARN, as reported in a United Kingdom study, is one case in 1.6-2.0 million people.⁶ Typically, ARN presents in patients 20-60 years old,¹ with no known sex predilection.² Multiple viruses can cause ARN, from most common to least common: VZV, HSV, CMV and Epstein-Barr virus.³ There is also an age predilection in viral etiology. In older patients, infections are more likely caused by VZV or HSV-1,⁷ while in younger patients, infections are more likely from HSV-2.²

Clinical presentation and prognosis

ARN can be classified into two phases, the acute herpetic phase and the late cicatricial phase.⁸ In the acute phase, the patient presents with mild to moderate ocular pain, irritation, elevated IOP and a red eye.¹ Anterior-segment findings include episcleritis, scleritis, anterior granulomatous uveitis or, rarely, a hypopyon.⁸ During the acute phase, the most common posterior-segment findings are chorioretinal vasculitis, vitritis and retinal necrosis.¹ The necrotic lesions in the posterior segment occur when the virus proliferates and causes rapidly progressive necrosis of the retina, choroid and vitreous. These distinctive retinal opacifications are thought to be caused by either an excessive immune response to the virus or a buildup of the virus infiltration itself.² ARN starts in the peripheral retina and typically does not affect the posterior pole in the early stages; therefore, central vision can initially remain undisturbed.¹

In the late cicatricial phase, the posterior segment is more heavily involved in fast-progressing retinal necrosis and vitreal structural changes.³ Retinal necrosis is usually seen in the temporal periphery, extending towards the posterior pole. The areas of retinal necrosis develop rhegmatogenous retinal detachment in 50-75% of cases⁷ due to a thinned atrophic retina, weak retinal adhesions and vitreal traction.² The highest probability of an associated retinal detachment occurs on average at the third week after the onset of symptoms, but can occur as late as five months after.³ The late cicatricial stage is associated with occlusive vasculopathy including arteritis and phlebitis at the retinal and choroidal vasculature. As the disease advances into later stages, ARN can progress to affect the macula and optic nerve, which can result in poor visual outcomes of 20/200 or worse. The decrease in central vision is likely secondary to macular edema or ischemia, and optic nerve hyperemia, edema or

neuropathy.^{1,9} Though less commonly seen, ARN can also further progress and lead to proliferative vitreoretinopathy, sclerotic vessels and optic atrophy.¹⁰ Other less common presentations that can lead to a reduced visual outcome are hypotony, macular pucker, or macular hole.¹

Because ARN has a variable presentation with unpredictable levels of severity, the visual outcome is based on disease course and progression. If the diagnosis is made within the first two weeks of onset, and if treatment is initiated immediately, the probability of bilateral spread can be reduced and the patient has a better visual prognosis.³ Early treatment is important as it takes the antiviral medications approximately one week to halt progression of the necrosis.³ If no treatment is initiated, the infection and inflammation can self-resolve in 6-12 weeks, though the visual prognosis is likely to be worse than if the patient received treatment.¹

Laboratory testing and differential diagnosis

Identification of the causative virus in ARN is accomplished with polymerase chain reaction (PCR) analysis of viral DNA from fluid samples taken from either the anterior chamber or the vitreous. PCR testing has high (>90%) sensitivity and specificity in detecting VZV, HSV and CMV.⁸ While PCR is the standard for determining etiology, false negatives or atypical presentations of ARN can confound results and affect treatment and management.

Suggested laboratory tests in a patient presumed to have ARN (CBC, HIV, HSV-1, HSV-2, VZV, CMV, PPD, RPR/VDRL, ACE and toxoplasmosis)¹ are intended to identify viral, bacterial and parasitic etiologies. Usually, in cases that present with hypertensive uveitis (elevated IOP with intraocular inflammation), infectious etiologies are implicated.

When working up a patient for ARN, the clinician should rule out progressive outer retinal necrosis (PORN). PORN presents with a similar etiology, pathophysiology and presentation to ARN. PORN is described as a set of clinical manifestations including:

- a. full-thickness necrosis in the peripheral retina
- b. extremely rapid progression with propensity for bilateral involvement
- c. minimal intraocular inflammation
- d. poor response to treatment with high doses of IV antiviral therapy^{2,11}

The main differences between PORN and ARN are the patient demographics and speed of progression of the disease. PORN is usually seen in HIV-positive, immune-compromised patients with a CD4+ lymphocyte count less than 50 cells/ μ L.¹² Like ARN, PORN is characterized by a quickly progressing outer retinal necrosis; however, unlike ARN, PORN does not present with prominent intraocular inflammation or vitritis.¹¹ It also progresses more aggressively than ARN with more retinal hemorrhages and a characteristic “cracked mud” pattern of opaque yellow-white retinal lesions.¹² In addition to PORN, other differentials to keep in mind when seeing peripheral retinal necrosis include CMV retinitis, toxoplasmosis, syphilis, endophthalmitis, Behcet’s disease, pars planitis, sarcoidosis and intraocular lymphoma.⁸

Systemic treatment

Antiviral medications are considered the standard of care for ARN. The current standard is to use IV acyclovir (1,500 mg/m²) for 5-10 days followed by maintenance oral acyclovir (800 mg 5x/day) for 4-6 weeks.¹³ IV acyclovir is the preferred drug as it is less systemically toxic than IV ganciclovir and IV foscarnet.¹¹ The current recommendation is to treat the disease empirically upon initial ocular manifestation, prior to diagnostic confirmation by PCR, because the average time for antiviral medications to take effect in stopping the progression of retinal necrosis is seven days.³

Treatment with oral antivirals alone can also be considered in less severe forms of ARN.¹⁴ There is some ongoing debate about the efficacy of oral monotherapy in reaching therapeutic levels in the blood serum and its ability to resolve active retinal lesions and prevent contralateral involvement.^{5,9,15} However, this concern focuses mainly on oral acyclovir (800mg 5x/day) failing to reach therapeutic levels, thus, acyclovir is generally not used as oral monotherapy.¹⁴ Alternative antivirals that may be more effective, such as famciclovir, valaciclovir or valganciclovir, should be considered.

Famciclovir (500 mg TID) is widely used and has shown similar visual outcomes to IV acyclovir treatment.¹⁶ Valaciclovir (1g TID), an acyclovir prodrug, is a newer oral antiviral that is safe and well-tolerated with minimal side effects. It has been shown to reach similar plasma levels as IV acyclovir.^{5,17} Valganciclovir (900 mg BID), a ganciclovir prodrug, is effective against HSV and VZV and is thus able to treat ARN, PORN and CMV retinitis, which establishes it as a logical first-line treatment choice.^{8,16} However, due to its severe systemic side effects, valganciclovir is generally reserved for CMV retinitis or acyclovir-resistant ARN.¹⁶ Prodrugs are considered a good alternative because they are converted within the body and provide greater bioavailability of the drug.¹⁶ Though multiple studies claim the efficacy of oral monotherapy, until further evidence is provided,

IV antivirals remain the recommended standard of care.¹⁴

Following the resolution of ARN, maintenance treatment with oral antivirals is used in an effort to prevent ARN onset in the contralateral eye.¹

Other medications used in ARN treatment include oral prednisone, aspirin and warfarin. Steroids are used to decrease intraocular inflammation and improve visual outcome; however, steroids are not to be added until 24-48 hours after the start of antiviral treatment to assure adequate antiviral coverage prior to the addition of an immune-suppressing steroid.⁸ Intravitreal triamcinolone can be used to treat choroidal neovascularization if it develops.¹⁸ Blood thinners are used to prevent retinal ischemia, though there is no strong evidence for the benefits of these adjunct therapies.⁸

Ocular treatment

As stated in the prior section, standard of care for ARN is IV antiviral medication with the option of corticosteroids. In addition to systemic treatments, ocular-specific treatments are used to contain the disease and prevent progression to the contralateral eye, most notably antiviral intravitreal injections.^{16,19}

Intravitreal injections are considered the most direct and immediate treatment for ARN presenting with retinitis or active inflammation at the macula or optic nerve head. An intravitreal injection combined with antiviral therapy generally achieves a better visual outcome and reduces the incidence of a retinal detachment, as opposed to systemic treatment only.⁸ Commonly used antivirals for intravitreal injection are ganciclovir and foscarnet.⁹ Intravitreal ganciclovir and foscarnet are widely used as they are non-toxic to the retina.²⁰ As such, they are a prudent alternative for patients who have developed resistance or experience side effects to oral antiviral therapies.⁸

Topical treatments for ARN are dependent on the symptoms secondary to intraocular inflammation. Topical steroids are recommended to treat anterior-segment inflammation in combination with a topical cycloplegic for pain control.¹ Topical ocular hypotensive agents are also indicated should the patient have increased IOP.²¹ Generally, treatment of the underlying condition will resolve elevated IOP. Topical antivirals are not proven to be clinically effective in ARN and are not reported in the literature as a method of treatment or adjunct therapy.

Retinal detachment following ARN has been reported in up to 75% of cases;¹ therefore, prophylactic laser photocoagulation or retinopexy has been common practice. Historically, the benefits of prophylactic laser have been uncertain, but multiple reports in the literature indicate laser can reduce the likelihood of retinal detachment if applied within the first two weeks of disease onset.^{1,3,9} Prophylactic laser cannot stop the spread of retinitis. Instead, it is used to create a “new” ora serrata posterior to retinal holes that develop in thinning atrophic retina^{1,8} and prevent progression to retinal detachment. Laser can also be used to treat neovascularization that may develop from ARN.¹

When retinal detachment does develop with ARN, PPV is recommended with or without scleral buckle (SB) with either gas or silicone oil fill. Recent studies show PPV alone (without SB) has yielded similar or better visual outcomes than PPV with SB.^{3,9} In general, cases of retinal detachment secondary to ARN have improved visual outcomes with early PPV intervention.³

Case Review

This case illustrates key concepts and goals in the care of a patient with acute disease with rapid progression. The clinician must be careful to complete a detailed and comprehensive examination. Early ARN can present as anterior uveitis that, if misdiagnosed and mismanaged, can lead to poor visual outcomes. Moreover, ARN can mimic other viral necroses, which requires the clinician to be cognizant of the relevant differential diagnoses. In the case reported here, had the small patch of peripheral necrosis been missed in the early stages of the disease, initiation of treatment would have been delayed.

Of note, oral antiviral treatment for this patient was delayed by a day because no initial clinical manifestations had suggested viral etiology and because the lab results were not yet known. Lab results play an important role in determining whether the empirical treatment initiated is adequate for the type of viral infection. However, it is not always necessary to wait for lab results before initiating treatment in cases of ARN if the diagnosis can be confirmed clinically. In addition, the etiology of the retinal necrosis can be an indicator of the severity and visual prognosis of the disease.

The most critical role for optometrists is to recognize the signs and symptoms of ARN for an accurate and prompt diagnosis. It is also in the patient's interest for the optometrist to order the indicated lab tests and make appropriate referrals to expedite diagnosis and treatment. Furthermore, the optometrist can be vital in treating signs, symptoms and pain with topical medications as was done in this case at the initial emergency room visit. Optometrists can also play an important role in educating patients about the progression and prognosis of the disease. Informing patients about ARN and available treatment

options not only improves their understanding but also may allow them to feel some control over a potentially devastating disease. Because prognosis can vary, it is prudent to not promise specific visual outcomes during the course of the disease. A seemingly mild case of ARN in the acute herpetic phase can quickly deteriorate with the onset of the late cicatricial phase.

Assessment of Learning Objectives

Educators can evaluate students on the learning objectives and key points of this case report in several ways. First, the case can be presented through a PowerPoint or similar presentation accompanied by fundus and fluorescein angiography images and students can be asked to describe normal and abnormal findings. They should be able to accurately describe retinal necrosis and identify the association with an underlying condition. Through further dialogue, emphasis can be placed on correlating hypertensive uveitis with infectious etiologies and becoming familiar with the differential diagnoses and indicated lab tests for associated viral, bacterial and parasitical causes. The role of an optometrist in managing ARN, including familiarity with ocular topical treatment options and their efficacy, should also be discussed. This discussion could be extended if the educator wishes to expand the students' exposure to retinal treatments or oral and IV treatments for viral infections. Knowledge assessment can be through group case discussions or written or oral quizzes. Another suggestion is to role-play a doctor-patient interaction to teach students how to manage patient education and expectations regarding severity of the disease and how to discuss the necessary testing and convey the urgency of referral to a specialist.

Conclusion

ARN is a rapidly progressive retinal necrosis that can have poor visual outcomes if not diagnosed and treated early. Because progression typically does not stop until one week after starting treatment, it is important that optometrists are able to diagnosis the disease and initiate treatment as soon as possible in conjunction with a prompt referral to a retina specialist. The optometrist also plays an important role in patient education, including explaining the progression and prognosis of ARN and the necessity of treatments. Similarly, as the primary care provider, it is the responsibility of the clinician to encourage the patient to follow-up with specialists and, if possible, to order appropriate laboratory tests to determine etiology.

Topical treatments that can be initiated include steroids, cycloplegics and hypotensive agents to treat anterior uveitis and elevated IOP. In most states, optometrists are also able to initiate treatment with oral antiviral medications, but referrals to ophthalmology and infectious disease are highly recommended given that IV antiviral therapy is the standard of care. As primary care providers, it is vital that optometrists have the ability to precisely identify ARN. With timely diagnosis and treatment of ARN come a better visual prognosis for the affected eye and a higher likelihood of preventing involvement of the contralateral eye.

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“No Time to Finish”: Electronic Health Records Documentation and Time

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Introduction

The Office of the National Coordinator for Health Information Technology (ONC) defines electronic health records (EHR) as “digital (computerized) versions of patients’ paper charts.”¹ In 2009, the federal government passed the Health Information Technology for Economic and Clinical Health (HITECH) Act, which encouraged widespread adoption of EHR.² The reasons for encouraging EHR implementation were to reduce medical errors, reduce cost of clinical care through technology and improve quality of care.² The HITECH Act authorized the Centers for Medicare and Medicaid Services (CMS) to financially incentivize providers and hospitals that used certified EHR.² The criteria set by CMS for receiving financial incentives were termed “meaningful use.” Doctors and offices able to demonstrate meaningful use received financial payments. In 2015, CMS began administering financial penalties to doctors or hospitals that do not use EHR.² The healthcare field responded to the rewards and penalties by shifting to a predominately EHR-based documentation process for doctors and hospitals. Positive consequences of the shift included less likelihood of lost records, improved clinical statistics and increased legibility of doctor records. EHRs are now the standard in hospitals and medical offices across the country, including academic healthcare centers.³ EHR are present in all 23 U.S. optometric education institutions, at least in the main academic clinics.⁴ With EHR ubiquitous in health professions academic settings, an understanding of their impact on the delivery of education, patient care, provider job satisfaction and the workload of optometric educators and providers is needed.

The impact of electronic health records on the delivery of medical education has been investigated. Responding to an anonymous online survey, 59% of 1,515 trainees reported that clinical documentation in EHR decreased the quality of their education.⁵ Medical residents who responded to the survey reported that documentation requirements were onerous and excessive, and negatively impacted time spent with patients, overall patient care, physician well-being, time available for teaching and quality of resident education.⁵

Several studies identified increased time spent on electronic charting as an unintended consequence of EHR. A 2017 study involving 471 primary care physicians, Tai-Seale et al. found that over time physicians spent less face-to-face time with patients and allotted more time to EHR charting.⁶ In 2013, Block et al. reported that interns spent 12% of their time in direct patient care and 40% of their time using computers.⁷ Holmes et al. reported that increased time spent on EHR contributed to residents’ burnout.⁸

In optometric education, time spent on documentation was identified as a challenge in the 2018 study “Faculty Perceptions on the Impact of Electronic Medical and Health Records in Optometric Education in the United States and Puerto Rico.”⁹ Investigators surveyed 265 clinical optometric faculty members and reported a majority of respondents perceived time spent by students and faculty for documentation in digital records took away from time spent teaching.⁹ For most optometric educators, clinical sessions are composed of limited time for teaching and clinical productivity. Therefore, any additional task that potentially impacts time, such as charting within EHR, warrants investigation. Documentation in either a paper chart or an electronic chart takes time for an optometric educator, but we wanted to evaluate how EHR influence this and evaluate any potential unintended consequences of EHR charting. This exploratory study was a follow-up to the previously published study “Faculty Perceptions on the Impact of Electronic Medical and Health Records in Optometric Education in the United States and Puerto Rico.”⁹ Information about the time impact of EHR charting in the optometric environment is scarce. A search of PubMed, Medline and VisionCite using the MeSH (Medical Subject Headings) terms *electronic health record*, *time* and *documentation* revealed one article pertaining to optometry.

The purpose of this survey study was to investigate the perceived impact of charting time in EHR on the academic clinical environment.

Methods

All faculty members at optometry schools in the United States and Puerto Rico who were identified in the Association of Schools and Colleges of Optometry (ASCO) faculty database as having clinical responsibilities were eligible for inclusion in this study. The survey was developed from a review of the medical literature and the investigators’ clinical experience. The survey sought information about completion of EHR charting related to timely documentation, quality and quantity of clinical teaching

and clinical productivity. The survey consisted of 8 Likert response questions (2 questions about teaching, 3 questions about productivity, and 3 questions about timely documentation). Additional questions were asked about type of EHR used, number of years using, and time for teaching. Eight of the questions required a response along a six-point Likert scale (1 = never; 2 = rarely; 3 = occasionally; 4 = moderate amount; 5 = always; and 6 = not applicable).

In May 2018, a link to the survey was e-mailed to 800 optometric faculty members who met the inclusion criteria. The survey was administered via the web-based Survey Monkey system. The formatting of the survey by Survey Monkey ensured that each participant could respond only once. A comment section was included. The survey was resent to all participants two weeks after the initial deployment. Information obtained by the survey was confidential and anonymous. The survey is included in **Appendix A**.

The data were analyzed using IBM SPSS version 25 (Chicago, Ill.). Percent and proportion were calculated for questions 1 to 8. The comments were analyzed using a grounded theory approach. The authors identified relevant comments with emerging themes and reached a consensus on the themes.

The study proposal was reviewed by the Institutional Review Board at New England College of Optometry and given an exempt status.

Results

The survey response rate was 202/800 (25.25%). A response to each question was not mandated. The mean number of years respondents reported using EHR was 6.61 (SD = 3.45), with a range from 1 to 20 years. All respondents reported use of EHRs. Although 11 different systems were reported, Compulink (40%) and NextGen (36%) were cited most (**Table 1**). Responses to questions 1-8 are tabulated in **Table 2**. The majority of survey participants reported that chart completion during regularly scheduled clinical sessions occurred never/rarely (44%), occasionally (14%), moderately (22%) and always (19%). Forty-one percent of participants reported they always/moderately sacrificed quantity of teaching to complete charts, while 22% occasionally sacrificed quantity of teaching to complete charts.

TABLE 1
EHR Systems Reported in Survey

	Frequency	Percent	Valid Percent
compulink	77	39.7	39.7
QES	2	1.0	1.0
InterallWorks	6	3.1	3.1
ic	39	33.3	33.3
univisys	2	1.0	1.0
aditium	1	.5	.5
office	7	3.6	3.6
atthen	88	35.9	35.9
esChart	1	.5	.5
aditiumEHR	6	3.1	3.1
	3	1.5	1.5
all	194	100.0	100.0

Table 1.

[Click to enlarge](#)

	Never	Rarely	Occasionally	Moderately	Always	Total	Valid Percent
1. How often do you complete charts during regularly scheduled clinical sessions?	12 (44%)	17 (14%)	22 (14%)	17 (14%)	17 (14%)	85 (100%)	44%
2. How often do you complete charts during non-scheduled clinical sessions?	47 (22%)	28 (13%)	28 (13%)	22 (10%)	25 (12%)	150 (70%)	22%
3. How often do you complete charts during teaching sessions?	38 (19%)	21 (11%)	21 (11%)	17 (9%)	17 (9%)	114 (57%)	19%
4. How often do you complete charts during administrative sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
5. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
6. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
7. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
8. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
9. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
10. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
11. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
12. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
13. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
14. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
15. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
16. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
17. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
18. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
19. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%
20. How often do you complete charts during other sessions?	21 (10%)	17 (8%)	21 (10%)	17 (8%)	17 (8%)	84 (41%)	10%

Table 2.

[Click to enlarge](#)

TABLE 3
Survey Data (Binomial), Questions 1-8

Question	Response	Frequency
charts are completed during my regularly scheduled session	0 (Never)	118
	1 (Occasionally)	79
office notifies me in a public manner if my are not signed	0 (Never)	59
	1 (Occasionally)	144
add turn away a non-emergency walk-in to complete my charts	0 (Never)	189
	1 (Occasionally)	25
EHR system I use hinders me practice more by	0 (Never)	138
	1 (Occasionally)	84
complete my charts with the opportunity before the end of the clinic session	0 (Never)	172
	1 (Occasionally)	79
office time spent for teaching in order to be my charts prior to leaving clinic	0 (Never)	118
	1 (Occasionally)	84
office the quality of my clinical teaching in complete my charts prior to leaving clinic	0 (Never)	117
	1 (Occasionally)	87
edit my clinic schedule to ensure time to teach and finish my charts as a regular	0 (Never)	88
	1 (Occasionally)	143

Table 3.

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TABLE 4
Survey Data (Chi-Square Values and p-Values), Questions 1-8

Question	Chi-Square Value	p-Value
Q1	6.680412371	0.00974780
Q2	45.54638175	1.49E-1
Q3	106.8865979	4.71E-2
Q4	37.43523318	9.45E-1
Q5	8.70984456	0.00316496
Q6	3.484530082	0.06194472
Q7	32.98969072	9.26E-0
Q8	44.8134715	2.17E-1

Table 4.

[Click to enlarge](#)

Quality of teaching was reported to be sacrificed never/rarely (51%), occasionally (19%) or moderately/always (27%). Impact on patient care, the refusal to see a non-emergency patient, in order to complete charts, was reported as never/rarely (78%), occasionally (8%) and moderately/always (4%). Clinical productivity was reportedly sacrificed to teach and complete charts never/rarely (66%), occasionally (8%) and moderately/always (8%). Respondents reported a mean decrease in teaching hours of 1.75 (SD = 2.46, 95% CI [1.34 - 2.16]).

The results from questions 1-8 were converted to binomial data to apply chi-square analysis on the probability of a given response. The responses for each question were given either a 0 or 1. If the response was never or rarely it was given a 0. If the response was occasionally or almost always it was given a 1. **Table 3** shows the response, frequency and percentage for each question as binomial data. **Table 4** converts the binomial data to chi-square values and p-values to help determine if a response was significant or by chance. Table 4 shows the responses for each question were statistically significant.

In addition to the 200 survey responses, 68 comments were received (**Appendix B**). Themes emerged related to the impact of EHR documentation on time outside of the clinical session, professional development and teaching/patient care. Many comments highlighted the inability to complete charts during a clinical session, necessitating staying late, working unpaid extra time, and finishing charts at home or at other times. Several comments conveyed that chart completion took time away from professional development. Many comments described the time required to complete EHR charting as challenging to teaching and patient care.

Discussion

This survey study collected information on the perceived impact of time for documentation in EHR on clinical productivity, teaching, and personal/professional time. The survey responses, statistical analyses and survey comments revealed that timely EHR documentation was a major challenge in optometric education settings. The time demands for completing patient records with EHR have been documented in health care. Research has explored the number of hours demanded of providers for every hour they are in clinic. Within the clinic day, for every hour physicians provide face-to-face care to patients, they spend nearly two additional hours on EHR and desk work.¹⁰ Outside office hours, physicians spend another 1-2 hours of personal time each night doing additional computer and other clerical work.¹⁰

Clinicians in this survey commented on a number of factors related to not completing their records in a clinic session. Factors included the speed or design/layout of EHR systems, the amount of information input required, and that both student and faculty member must review the record.

Respondents commented that they often have to finish their records at other times during their week, either at work or at home. One person stated, "To clarify, my charts are almost never completed by the designated end of my clinic session, so I

stay late every clinic day to complete them.” Another reported, “I estimate that I spend two extra hours charting for a full clinic day with EHR compared to previously with paper charts.” And another noted, “I spend more of my own time after-hours completing records, less time for scholarship and service. I rarely let this compromise my clinical teaching.”

The demand for clinicians to finish their patient charts is multifactorial and contributes to the behavior of sacrificing time from other activities to complete records. One factor is the time requirement for processing billing for the visit. EHR are linked to hospital and clinic billing departments. In most clinics if a clinician does not finish his or her charts in a timely manner it could affect the insurance reimbursement. The potential for documentation mistakes is also a factor. The longer a clinician takes to finish a record, the greater the likelihood of documentation errors.¹¹ Clinics and hospitals set time requirements for clinicians to follow so charts are documented in a timely manner, and practicing clinicians know they have to meet the requirements or be concerned about potential consequences. The survey comments revealed that other areas of faculty members’ professional and personal lives may be sacrificed in order to get charts done. One respondent wrote, “Completing EHR doesn’t reduce my teaching time in clinic, but it does reduce my development time for other projects.” Faculty who participated in the survey reported that time spent on service and scholarship are impacted because they use that time to complete their EHR from clinic sessions.

The survey also asked about time spent teaching optometric interns as it relates to the time clinicians need for charting. Responses revealed that at times clinicians choose to reduce the amount of time they spend teaching optometric interns in clinic because that time is needed to finish charts. However, respondents also provided comments indicating they do not sacrifice time for teaching and instead spend time outside of clinic hours to finish charting work. One respondent wrote, “Rather than sacrifice teaching or patient care, I typically stay extra hours or delay other administrative stuff to get my charts done.” Another wrote, “I don’t sacrifice clinical teaching to finish charts. The student has 24 hours to submit the chart, so I spend extra development time and office hour time, just doing my charts.” Optometric clinical educators should be commended on their commitment to clinical education despite the increase in time it takes to complete patient records.

In academic clinical environments, each clinical session allows a limited amount of time for teaching and clinical productivity. Clinical productivity implies sustainability for most clinics. Therefore, time devoted to clinical productivity, including providing a high level of patient care, usually must be maintained.

Survey respondents revealed in their comments that sacrifices have to be made to complete patient documentation. The time demanded by the need to complete patient charts has increased in the EHR era. Personal time, time with family, and professional development were cited by survey respondents as areas they sacrificed. Staying late, arriving to clinic early or finishing charts during other times were common themes among respondents. Respondents also commented that this extra time is an increase in hours spent working and unpaid. One respondent shared, “I think the question is not whether the charts are finished within the session time, the argument is HOW much time OUTSIDE of the clinic session is dedicated to completing EHR patient charts. I regularly spend HOURS after clinic sessions, or on the day AFTER seeing patients finishing charts. I would submit that for every hour in clinic (seeing patients, teaching, etc.) I spend between 35 and 45 minutes working on EHR related items. It has not cut into teaching time, but has PROFOUNDLY affected personal time before and after clinic sessions in my own personal time.” Another respondent noted, “I have chosen to prioritize teaching time, however the hours spent evaluating and finalizing charts is overwhelming and amounts to a lot of unpaid over-time.”

In a 2018 study, investigators explored the association between electronic health records and burnout among psychiatry residents and faculty.¹² The study utilized a “burnout” survey and revealed that psychiatry residents and faculty showed signs of high emotional exhaustion, which was associated with burnout. The results demonstrated a high positive correlation between EHR use and burnout. Based on their survey results, the investigators concluded that EHR use may be an important area for program directors to monitor as they evaluate their psychiatric educators in seeking to minimize burnout and promote an environment of longevity and wellness.¹² A study published in the *Journal of Graduate Medical Education* investigated EHR effects on work-life balance and burnout among primary care residents and faculty.¹³ Residents and faculty in 19 primary care programs were surveyed on work-life balance, burnout and EHR use. The exploratory study showed that more after-hours time spent on EHR was associated with burnout and less work-life satisfaction.¹³

The majority of clinical educators are given time for scholarship and service to promote their academic careers. Survey respondents commented that they often use that time to finish EHR charting from a previous clinical session. Sacrifices in personal and professional time may affect the sustainability, job satisfaction and longevity of clinical educators. The widespread shift to EHR use has brought benefits and costs. Access to information and statistical analysis have improved with EHR, but do those benefits outweigh the time it takes an optometric educator to document? Could the amount of time it takes to complete documentation with EHR adversely affect retention of clinical faculty members? Optometric education institutions may need to address this question as well as how EHR affect faculty satisfaction and work-life balance.

Limitations

The limitations of this study were response rate, question design, respondent bias and lack of data related to the respondents' specific institutions. The response rate was 25.25%. This did not reflect responses from the majority of clinical educators across the optometric education field. The study explored only the perception of these 25%, which could vary from the majority. Therefore, the generalizability of the study may be impacted.

Some respondents commented that some of the questions were not clearly stated. For example, in Question 2 (My office notifies me in a public manner if my charts are not signed), the meaning of "public manner" was not provided. In Question 5 (I complete my charts with the optometry student before the end of the clinic session), the time length for a clinical session was not defined. In Question 10 (Estimate the number of hours your clinic teaching time has decreased since using EHRs in your clinical setting) the number of hours per day, week or month was not explicitly stated. Therefore, these questions relied on the interpretation of individual respondents. Another limitation of the study was that although it was anonymous, which should encourage honesty, it is possible that respondents did not want to honestly admit they are spending less time teaching or that the quality of their teaching has decreased because of EHR, representing a bias towards good teaching. This type of admittance can be held back even in an anonymous survey. To protect anonymity, data was not collected regarding the name of the institution of each respondent. Therefore, a large number of respondents may have been from one institution, introducing a potential bias.

Conclusion

An unintended consequence of EHR is increased time needed for documentation. Clinical faculty are particularly impacted because both student and faculty member need to complete and review documentation. The results of this study indicated that time spent on documentation within an EHR impacts aspects of clinical faculty members' personal and professional lives. Uncompensated time for documentation may have an impact on recruitment, retention, professional development and career satisfaction for faculty members. Future studies are needed to quantitatively document how much additional time is needed to complete documentation within EHR in different clinical scenarios. Clinic and academic administrators may need to explore appropriate compensation for the additional time demands of EHR.

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Appendix A Electronic Health Records (EHR) Impact on Optometric Education Survey

As optometric educators, we are seeking your expertise on how EHR affect your teaching during clinic. This short 10-question survey is a follow-up to a larger study conducted two years ago and can easily be completed in less than five minutes. Your answers are strictly confidential and anonymity will be maintained. Thank you in advance for your participation. Please use the responses below to answer the following:

- 1) **My charts are completed during my regularly scheduled clinic session**
(1) Never (2) Rarely (3) Occasionally (4) A moderate amount (5) Always (6) Not applicable
 - 2) **My office notifies me in a public manner if my charts are not signed**
(1) Never (2) Rarely (3) Occasionally (4) A moderate amount (5) Always (6) Not applicable
 - 3) **I would turn away a non-emergency walk-in patient to complete my charts**
(1) Never (2) Rarely (3) Occasionally (4) A moderate amount (5) Always (6) Not applicable
 - 4) **The EHR system I use helps me practice more efficiently**
(1) Never (2) Rarely (3) Occasionally (4) A moderate amount (5) Always (6) Not applicable
 - 5) **I complete my charts with the optometry student before the end of the clinic session**
(1) Never (2) Rarely (3) Occasionally (4) A moderate amount (5) Always (6) Not applicable
 - 6) **I sacrifice time spent for teaching in order to complete my charts prior to leaving clinic**
(1) Never (2) Rarely (3) Occasionally (4) A moderate amount (5) Always (6) Not applicable
 - 7) **I sacrifice the quality of my clinical teaching in order to complete my charts prior to leaving clinic**
(1) Never (2) Rarely (3) Occasionally (4) A moderate amount (5) Always (6) Not applicable
 - 8) **I modify my clinic schedule to examine less patients in order to teach and finish my charts on a regular basis**
(1) Never (2) Rarely (3) Occasionally (4) A moderate amount (5) Always (6) Not applicable
 - 9) **Which EMR do you primarily work with?**
a) CompuLink
b) NextGen
c) Epic
d) eClinicalWorks
e) Athena
f) Other
- Please fill-in your responses to the following:
- 10) Estimate the number of hours your clinic teaching time has decreased since using EHR in your clinical setting
 - 11) How many years have you been using an EHR in your academic practice? (If less than one year, report 1.)
 - 12) Please provide any additional comments if you desire:

Appendix A. Click to enlarge

Appendix B. Click to enlarge

- What are electronic health records (EHRs)? [Internet]. Washington D.C.: HealthIT.Gov; [cited 2019 June 6]. Available from: <https://www.healthit.gov/topic/health-it-and-health-information-exchange-basics/what-are-electronic-health-records-ehrs>
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Non-Arteritic Ischemic Optic Neuropathy with Serous Macular Detachment: a Teaching Case Report

Jill Gottehrer, OD, FAAO, and Joseph Gallagher, OD, FAAO | Optometric Education: Volume 46 Number 1 (Fall 2020)

Background

Non-arteritic ischemic optic neuropathy (NAION) is an ocular condition that typically presents in individuals age 40-60 with unilateral, painless vision loss, mostly upon awakening. There are 1,500 to 6,000 new cases in the United States every year.¹ NAION is typically diagnosed based on its clinical features with the aid of ancillary testing. We present a case of NAION with concurrent serous macular detachment in a 68-year-old male. We review the clinical presentation, ancillary testing, differential diagnosis and potential complications of NAION. The intended audience is third-and fourth-year optometry students, optometry residents and current practitioners.

Case Report

A 68-year-old Caucasian male presented to the eye clinic on referral by his primary care physician. His chief complaint was blurry vision in his left eye with being unable to see the inferior half of his visual field for approximately two weeks. He denied concurrent symptoms such as jaw claudication, scalp tenderness, malaise, fever and weight loss. The patient reported having cataract surgery in both eyes two months prior with no postoperative complications and greatly improved vision. His medical history was significant for hypertension, benign hypertrophy of the prostate, esophageal reflux, hiatal hernia, eczema and personal exposure to Agent Orange. His current medications included lisinopril 40 mg once daily in the morning, omeprazole 20 mg once daily and aspirin 325 mg once daily. The patient denied having any allergies.

Unaided visual acuity measured 20/20 OD and 20/150 OS with eccentric fixation. There was no improvement in visual acuity in the left eye with refraction. Refractive error was -0.25 D in the right eye and plano in the left eye. Cover test revealed orthophoria at distance and near without correction. Extraocular muscle movements were smooth, accurate, full and extensive. Confrontation visual field using fingers was full in the right eye and indicated an inferior defect in the left eye. Pupils were equal, round and reactive to light, and a 1+ afferent pupillary defect was observed in the left eye.

The anterior segment was examined by slit lamp biomicroscopy. Lids, lashes, conjunctiva, sclera, cornea and iris were clear OU. Intraocular pressure measured with non-contact tonometry at 2:44 p.m. was 17 mmHg OD and OS. The pupils were dilated with one drop each of tropicamide 1% and phenylephrine 2.5% in each eye.

The posterior segment was examined with a slit lamp biomicroscope with a 90D lens and a binocular indirect ophthalmoscope with a 20D lens. Each eye exhibited a well-centered posterior chamber intraocular lens. The vitreous of both eyes showed mild syneresis.

The posterior pole of the right eye revealed a healthy optic nerve with cup-to-disc ratio of 0.15 with well-perfused rim tissue. The macula appeared normal. The vessels of the right eye had an artery-to-vein ratio of 2/3 with mild tortuosity. The periphery of the right eye showed a chorioretinal scar superior-temporal and inferior-temporal in a circinate-like pattern.

The posterior pole of the left eye revealed a full optic nerve with no visible cupping and 3+ edema with flame-shaped hemorrhages on the temporal edge of the disc. It also showed mild edema in the macula. Additionally, the vessels had an artery-to-vein ratio of 1/3 with mild tortuosity and crossing changes superior-temporal. The periphery of the left eye was unremarkable 360 degrees.

A Humphrey 24-2 visual field test was performed (**Figure 1**). The right eye showed a shallow cluster of adjacent points inferior-nasal, inferior crossing midline and inferior-temporal, almost like an arcuate pattern. The left eye showed an inferior altitudinal defect.

Optical coherence tomography (OCT) of the optic nerves (**Figure 2**) and macula (**Figure 3**) was acquired using a Spectralis OCT. Additionally, fundus photos were taken using a Zeiss camera (**Figure 4**). In addition, the patient was sent for lab work after his eye examination to rule out conditions such as giant cell arteritis. Both CRP and ESR were ordered by the optometry clinic. A carotid duplex scan and HbA1c were ordered by the primary care physician. The results of the CRP and ESR came back later that day as normal.

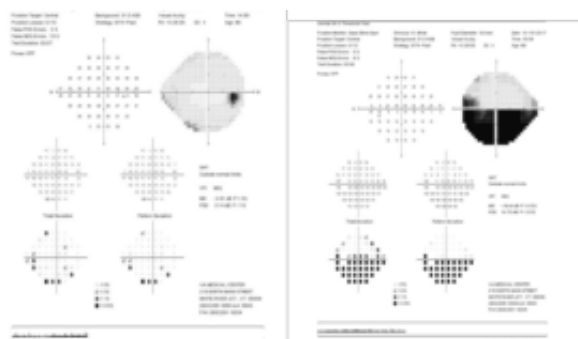


Figure 1. Sita Standard Humphrey visual field testing at the initial visit shows no defects OD (left) and an absolute inferior altitudinal defect OS (right). [Click to enlarge](#)

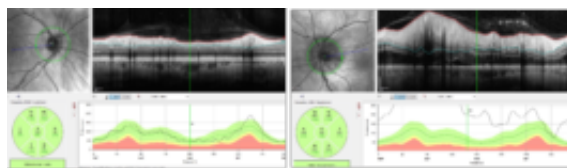


Figure 2. Spectralis OCT imaging of the retinal nerve fiber layer at the initial visit shows no optic nerve head edema OD (left) and peripapillary edema OS (right). [Click to enlarge](#)

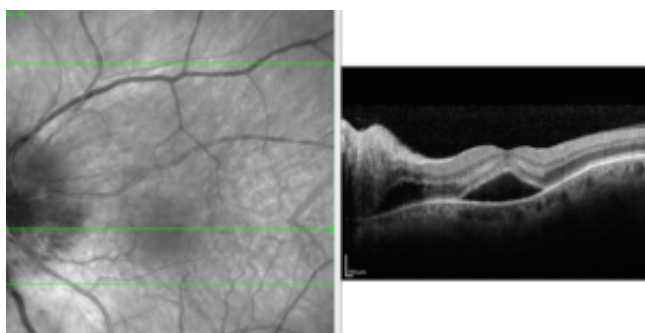


Figure 3. Spectralis OCT imaging at the initial visit shows serous macular detachment OS. [Click to enlarge](#)

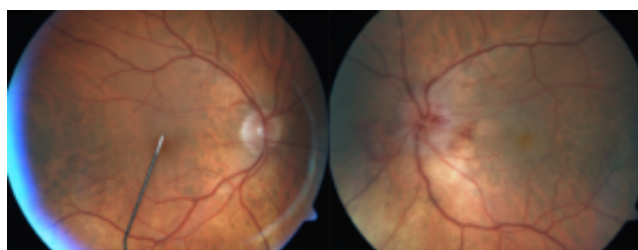


Figure 4. (left): Fundus photography at the initial visit shows a normal appearance OD (left) and optic nerve head edema with flame-shaped hemorrhages and macular edema OS (right). [Click to enlarge](#)

The patient was diagnosed with presumed NAION with serous macular detachment in the left eye. He was instructed to take his blood pressure medication in the morning, with his primary care physician's approval, to try to lower the risk of recurrence. He was referred to a retinal specialist for evaluation of the serous macular detachment.

Education Guidelines

Learning objectives

At the end of the case discussion, participants should be able to:

1. List the differential diagnoses of NAION
2. Explain how to appropriately diagnose NAION
3. Describe the pathophysiology and risk factors associated with NAION
4. Understand treatment and management of NAION
5. Discuss the expected prognosis and complications for patients diagnosed with NAION

Key concepts

1. Ocular signs and symptoms of NAION
2. Systemic and ocular causes of NAION
3. Pathophysiology of NAION
4. Treatment and management of NAION

Discussion questions

1. Knowledge and concepts required for critical review of this case:
 - a. Describe the epidemiology, pathophysiology and risk factors associated with NAION
 - b. Describe the key clinical findings in patients with NAION

2. Differential diagnosis:

- a. Characteristic signs of NAION
- b. List appropriate differential diagnoses for NAION

3. Disease treatment and management:

- a. What is the standard of care to treat a patient with NAION?
- b. Discuss the most likely prognosis and possible complications following treatment of a patient with NAION
- c. What is the appropriate follow-up schedule of a patient with suspected and confirmed NAION?
- d. Which specialist(s) should be involved in the care of a patient with NAION?

4. Patient education:

- a. How would you educate the patient regarding the suspected diagnosis?

5. Critical thinking:

- a. How would you have managed this case? Justify your answer based on the findings.
- b. What would have been a sign of poor prognosis?

Teaching Instructions

This case report can be taught using a problem-based-learning (PBL) methodology. The discussion points can be used to facilitate discussion and achievement of the learning objectives as outcome measures. In either a large- or small-group setting, participants should be presented with sections of the case. For example, case history can be presented in its entirety or as a role play, while students ask the facilitator relevant case history questions. Students would then be tasked with developing differential diagnoses and collecting data sufficient for ruling out each differential. The case would proceed in traditional PBL format with analysis of data, determination of a diagnosis and determination of a management plan supported by evidence-based decision-making. Additional discussion may involve a review of information contained in the literature search and discussion of the use of other clinical testing not mentioned in this case report.

Describe the epidemiology, pathophysiology and risk factors associated with NAION

Males and females are affected equally with NAION. It tends to affect Caucasians more than any other race. NAION is caused by reduced perfusion to the optic nerve. A decrease in autoregulation occurs and affects those with a “disc at risk” or a small, crowded optic nerve resulting in axonal degeneration and loss of retinal ganglion cells via apoptosis.² Another ocular risk factor is optic nerve head drusen. Common systemic risk factors for this occurrence include diabetes mellitus, hypertension, migraines, obstructive sleep apnea, hyperlipidemia and arteriosclerosis. Taking blood pressure medication at night can lead to nocturnal hypotension and thus hypoperfusion of the optic nerve.³ Systemic phosphodiesterase 5-inhibitors⁴ and amiodarone⁴ have also been linked to NAION, although the link is controversial.

Describe the key clinical findings in patients with NAION

NAION and arteritic ischemic optic neuropathy (AION) may present similarly with sudden vision loss and a positive afferent pupillary defect. Although the vision is typically worse in patients presenting with AION, on fundoscopy the nerve is also swollen, and will exhibit pallor, with flame-shaped hemorrhages and cotton wool spots. Therefore, case history is important. The patient should be asked about recent temporal headaches, jaw claudication, malaise, fever and weight loss. AION can cause loss of vision or loss of life; therefore, it is imperative to perform lab tests including ESR, CRP, CBC and, if necessary, temporal artery biopsy to differentiate from NAION.

Characteristic signs of NAION

Visual acuity can range from 20/40 to 20/70 on presentation. Additional evaluation to aid in diagnosis includes careful examination of the pupils, visual field testing and OCT. Often a new afferent pupillary defect is present. In addition, a visual field test will show a classic altitudinal defect in the affected eye. Most commonly this impacts the inferior half of the visual field. OCT is quite beneficial as it can show the amount of swelling to the optic nerve at initial presentation and help monitor changes as the swelling decreases. Fundus photography can also be useful in monitoring changes to the appearance of the optic nerve as the edema resolves. Color vision testing/red cap desaturation does not aid in the clinical diagnosis of NAION; however, it may be performed if the patient reports new color vision changes.

NAION primarily comes in two forms: non-progressive and progressive. With non-progressive NAION, there is a sudden decrease in visual field and visual acuity, which stabilizes. With progressive NAION, there is a sudden decrease in visual field and visual acuity followed by a further decline approximately three weeks later. This is seen in approximately 30% of cases.

List appropriate differential diagnoses for NAION

- AION: Must be ruled out, as this is a sight-threatening and life-threatening condition. The patient in this case denied symptoms including scalp tenderness and jaw claudication, but blood tests can help exclude this diagnosis.
- Posterior ischemic optic neuropathy: Although this patient has monocular vision loss with a positive afferent pupillary defect, there is visible damage to the optic nerve, which excludes this diagnosis.
- Hypertensive retinopathy: This patient's systemic history is positive for hypertension; however, it was not highly elevated at the time of his examination. Fundus examination did not show hemorrhaging or cotton wool spots extending into the peripheral retina.
- Central retinal vein occlusion: Although a cause of unilateral, acute vision loss, hemorrhages are generally seen beyond the peripapillary area. Additionally, the retinal veins are dilated and tortuous.
- Branch retinal vein occlusion: Can also be a cause of unilateral, acute vision loss. However, the optic nerve is typically not involved.
- Optic nerve infiltration: This is a cause of unilateral optic nerve head edema. However, in this case, there was absence of other systemic associations, such as lymphoma. This also does not typically cause flame-shaped hemorrhages to the optic nerve.
- Optic nerve/orbital tumors: A differential of unilateral optic nerve head edema. This also does not typically cause an altitudinal visual field defect.
- Foster Kennedy syndrome: Unlikely as the patient's fellow optic nerve is not atrophic. Also, the patient displayed no unusual behavioral symptoms.
- Optic neuritis: Less likely given the patient's age and gender. The exam findings, such as normal extraocular eye movements, help exclude this diagnosis.
- Leber's optic neuropathy: This does not fit the patient demographic as it is typically seen in young men. Additionally, it begins unilaterally then becomes bilateral.
- Optic disc drusen: The disc itself in this case is not actually swollen and the surrounding nerve fiber layer is normal. A B-scan could help aid in this diagnosis by finding buried optic disc drusen.
- Graves' disease: Can cause optic nerve compression due to thickened extraocular muscles. This is the opposite of the patient's ocular presentation. Also, there was a lack of ocular signs/symptoms including diplopia, lid retraction and lid lag.

What is the standard of care to treat a patient with NAION?

There is no treatment for NAION. In a study by Hayreh, improvement in visual acuity with systemic corticosteroids was demonstrated by reducing optic nerve head edema by reducing capillary permeability.⁶ However, due to the lack of randomization in this study, it is not widely accepted.

In the Ischemic Optic Neuropathy Decompression Trial, which followed 250 patients with NAION from October 1992 to October 1994, optic nerve decompression was found not only to be of no benefit to those with NAION but harmful as well.⁷

Discuss the most likely prognosis and possible complications following treatment of a patient with NAION and the appropriate follow-up schedule of a patient with suspected and confirmed NAION

Patients tend to recover 2-3 lines of visual acuity on their own in 6-8 weeks. There is no recovery of the visual field defect.⁸

Which specialist(s) should be involved in the care of a patient with NAION?

NAION should be handled by a multidisciplinary team: the eyecare provider to make the diagnosis and an internist to order laboratory tests and determine if it's safe for the patient to take his or her blood pressure medication at nighttime.

A serous macular detachment is an unusual finding with NAION; therefore, referral to a retinal specialist should be made. The edema from the optic nerve can seep into the macula, causing this occurrence. A macular OCT can capture this finding as well as changes as the patient recovers. A study performed in 2008 by Thomas R. Hedges, MD, et al. showed 8 of 76 patients had subfoveal fluid from NAION captured on macular OCT. In these patients, the macular fluid subsided with no intervention as the optic nerve healed on its own, thus patients can gain some lines of visual acuity.¹⁰ A few case reports have described successful use of anti-VEGF injections to decrease macular fluid and improve vision in NAION. Anti-VEGF injections may also reduce optic nerve edema to promote faster recovery.¹¹

How would you educate the patient regarding the suspected diagnosis?

Because the risk of NAION occurring in the fellow eye is 15-20%,⁹ it is crucial to advise patients to reduce systemic risk factors such as smoking, diabetes, hypertension and hyperlipidemia. In addition, it's recommended that patients take their blood pressure medication during the day if possible in order to reduce nocturnal hypoperfusion. Daily aspirin is also recommended.⁹

Discussion

The patient in this case report was diagnosed with NAION based on his ocular symptoms, signs, systemic history, ancillary testing and laboratory tests. His age (68) and acute painless vision loss excluded some differential diagnoses such as Leber's optic neuropathy and optic neuritis. Pupil testing and the observation of a positive afferent pupillary defect were key as they helped indicate the presence of retinal ischemia. Dilated fundus examination was possibly the most important component in this case as it showed the retinal findings, narrowing the list of differential diagnoses. The patient's systemic history of hypertension and small cup-to-disc ratio in the right eye (0.15) were hints that NAION was causing his symptoms. Another crucial component in this diagnosis was the ancillary testing. The altitudinal visual field defect was another clue that the patient's symptoms were caused by NAION. However, AION could not be excluded without the appropriate laboratory tests. With CBC, CRP and ESR all revealing normal results, the final diagnosis was NAION.

Conclusion

Patients affected by NAION should be monitored carefully. Aside from the appropriate ancillary testing to confirm the diagnosis, lab work should be done urgently to rule out AION. In addition, thorough patient education and appropriate management are needed to reduce systemic risk factors and the likelihood of NAION development in the fellow eye. When serous macular detachment accompanies NAION, referral to a retinal specialist for anti-VEGF injection should be considered. Anti-VEGF injection may reduce macular and optic nerve edema.

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Call for Papers for Theme Edition: Diversity and Cultural Competence in Optometry

| Optometric Education: Volume 46 Number 1 (Fall 2020)

The population continues to become more diverse, and optometry must be able to meet the cultural, ethnic, racial, gender and linguistic needs of patients. *Optometric Education* is inviting authors to submit scholarly papers addressing related themes such as diversity, cultural competency, gender issues and cultural awareness.

The deadline to submit papers for this theme edition is **March 30, 2021**

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Using an Audience Response System in a First-Year Optics Course: Student Perceptions and Outcomes

Frank Spors, EurOptom, MS, PhD, Dorcas K. Tsang, OD, Krystle Golly, MS, and Joseph Gray, OD | Optometric Education: Volume 46 Number 1 (Fall 2020)

Background

Face-to-face lectures are often used for delivering significant amounts of content to large groups of students. The effectiveness of one-way lectures that do not actively engage students is limited. Adults passively attending a lecture have a maximum attention span of 15 to 20 minutes, and research has shown a low rate of information retention when audience members are passive participants in the learning process.¹⁻³ On the other hand, students who actively engage during lecture — who interact with one another as well as with the instructor — have a better understanding of the lecture material, retain it longer, and are more able to apply the concepts in other contexts.⁴ While the ability to maintain attention in class may depend on the student's level of motivation, interest and cognitive processing aptitude, attention itself may be influenced by the presentation of the lecture material, over which the instructor exerts full control.^{5,6} To actively engage students during lecture, many instructors have implemented innovative technologies.³

These technologies include audience response systems (ARS), which have been increasingly used in education. An ARS is a combination of hardware and software that enables the instructor to pose real-time questions to students. The required hardware may be physical “clickers,” or the responder's smartphone, laptop or tablet. During the live presentation of class materials, students are prompted to answer questions using their response devices. As responses are submitted via the software portal, the software instantaneously analyzes and displays a histogram showing the distribution of responses among answer choices. This particular tool not only assesses student learning to provide the instructor immediate feedback, but also promotes participation and engagement essential in active learning. Therefore, an ARS is beneficial to both the students and the instructor during the ongoing lecture.⁷ The instructor can instantly decide if a topic needs to be reviewed or if the lecture can proceed, while the students can self-reflect on their level of understanding of the concept just covered.⁸ Compared with traditional lectures, sessions using an ARS allow implementation of a variety of question types, including multiple-choice, multiple-response, fill-in-the-blank, matching, ordering, free-text response and hot-spot (click-on-target) picture questions. When used appropriately, this takes advantage of the valuable face-to-face time in class and can support active learning by requiring students to be engaged in higher-order thinking and analysis to synthesize and evaluate the materials presented to them in the classroom.⁹ According to Premkumar and Coupal, a 90-minute lecture should have a minimum of 5-6 engagement questions.¹⁰ Approximately 3-4 minutes should be devoted to the administration of each question, its response collection and any follow-up discussion of the correct solution. The utilization of the ARS provides an opportunity to improve the quality of analysis and discussion of lecture content, while at the same time providing immediate feedback to the course instructor.¹¹ Therefore, it can play a vital role in transforming didactic teacher-centered lectures into interactive learner-centered environments, where students can engage in peer discussions and collaborative learning.¹² To efficiently use an ARS throughout a lecture, a selection of assessment questions can be utilized. The three primary categories of ARS assessments are: factual recall, conceptual understanding and knowledge application. Factual recall assessments are often used to determine if students have done assigned readings or paid attention to rules and concepts stated during the lecture. Conceptual assessments require students to create answers rather than recall them and tend to generate more substantive discussions. Knowledge application assessments require analysis of concepts in different contexts and lead to a higher order of learning.³

Despite its great potential, using an ARS *per se* does not guarantee improved face-to-face lectures, actively engaged students or improved student learning. In a 2004 commentary, biology professor William B. Wood noted, “Like any technology, these systems are intrinsically neither good nor bad; they can be used skillfully or clumsily, creatively or destructively.”¹³ The implementation of pedagogical strategies in combination with ARS technology is what ultimately influences student success.¹⁴ The reasoning for using an ARS should be explained to the students at the beginning of the course. Conceptual questions, each focusing on key points of the lecture, need to be prepared prior to the lecture, and students should be motivated to engage with the material and to answer the questions. In this context, the discussion of the presented ARS questions among the students is important. While the instructor strives to present the material as clearly as possible during an ongoing lecture, some students might still misunderstand or analyze the content incorrectly. On other occasions, students might understand the lecture material but misunderstand an ARS question. Both problems may be corrected by the students themselves during small-group discussions, a process that was introduced as Peer Instruction by physics professor Eric Mazur.¹⁵

Mazur's Peer Instruction method is a three-step process. The first step involves introducing an ARS question for formative

assessment and having the students submit their responses individually. Students are then asked to engage in small-group discussions to convince each other of the correctness of their own answer by explaining their underlying analysis. In the last step, the instructor presents the same question, polls the students again, and provides support for the correct solution.¹⁶ Peer Instruction is a proven method to improve student learning for the mastery of lecture material.¹⁷ It is, however, time-consuming and requires that students complete reading assignments on the lecture topics before coming to class. An alternative approach is to have students engage in small-group discussions right after the question is assigned, which is then followed by one-time voting by each student.^{14,18,19} Unlike asking informal questions during a lecture, which typically engages only a few highly motivated students, an advantage of answering questions following small-group discussions is that it involves every student. In this context, the use of an ARS is vital for soliciting responses of all students in the class.

A substantial amount of literature documents improvements in student motivation and engagement in higher education due to the use of ARS.^{3,7,8,11-14,18,20-26} Although students tend to prefer a teaching style that incorporates an ARS during lecture, reports on whether this has a positive effect on examination grades have shown mixed results.^{2,18-20,24-29} To examine the potential impact of an ARS on students' performance on graded tests and to optimize its use in class, their input regarding their perceptions of ARS in the learning process is crucial. To investigate student perception of ARS in the learning process, the study reported here involved first-year optometry students who participated in a geometrical and ophthalmic optics course during which an ARS was utilized in every 90-minute lecture.

The purpose of this study was two-fold. The first purpose was to examine student experiences with the Top Hat ARS with feedback regarding the administration of ARS questions throughout the course. The second purpose was to analyze the inter-cohort performance on examination items compared with performance in the same course taught the previous year during which no ARS was used.

Methods

Audience response system

The ARS used during this study is a web-based platform called Top Hat (Tophatmonocle Corp., Toronto, Canada). It leverages the mobile devices that students already own, such as smartphones, laptops and tablets. The Top Hat platform does not require students to purchase clickers. Instead, they purchase a license to use the software on their mobile devices. At the time this paper was written, the regular pricing was \$48 per student for one academic year, but special pricing may apply based on institutional agreements. In addition to ARS questions, the software can host all lecture materials, including presentations, text documents and videos. Therefore, it is possible to quickly set up questions, move them within presentations if needed, and administer lectures completely out of the Top Hat platform. Because a gradebook function is included, the software can host entire courses. Each session or quiz has a unique Join Code. If required, geofencing can be enabled by the instructor for each session to ensure that only students who are physically in attendance can participate. Typically, a student roster is linked from the learning management system to the Top Hat platform, which enables a variety of functions such as formative and summative assessments, segmentation of questions, targeted item analysis, attendance tracking and certain gradebook items to sync at the discretion of the instructor. In addition, extensive reports and analyses can be generated for monitoring individual student performance throughout a course, which is helpful in identifying at-risk students. The Top Hat software allows questions to be delivered in multiple ways: during lecture, assigned as homework, or assigned for review. **Figures 1-3** show the in-class look.



Figure 1. Example of what students see prior to the display of lecture slides and audience response questions. The Join Code is unique for each presentation or quiz and is only required at the beginning of a session. The instructor can start or cancel the presentation from this screen and take attendance. The display format can be customized via the options at the bottom right. [Click to enlarge](#)



Figure 2. Example of how a multiple-choice question is displayed during administration. A question timer can be added when the question is constructed or when it is administered via the button in the top right corner. The bottom navigation bar allows the instructor to open, skip or close the question; to show the students' responses after the question is closed; and to display the correct answer. [Click to enlarge](#)

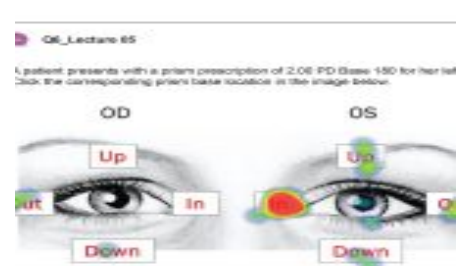


Figure 3. Example of a hot-spot (click-o-target) question after the students have submitted their responses. A warmer color indicates an increased number of responses. The area for the correct response can be defined during the construction of the question. [Click to enlarge](#)

Participants and course

Eighty-four first-year optometry students at Western University of Health Sciences College of Optometry, Pomona, Calif., used their smartphones, laptops or tablets as their ARS response devices to answer questions strategically placed in each 90-minute lecture of a geometrical and ophthalmic optics course. The semester-long course was the first in a sequence of four optics courses and was delivered in a traditional face-to-face format. The slide decks of all lectures were uploaded into the Top Hat platform, so the questions could be placed within each slide deck. Attendance in the course was mandatory, and the responses to the ARS questions served as the attendance tracker. This was the first encounter the students had with an ARS in the optometry program.

ARS questions and small-group discussions

At the beginning of the course, the instructor explained that ARS questions would be used for formative assessment in conjunction with small-group discussions, and demonstrated how to access and use the Top Hat platform. Throughout the course, the instructor inserted 5-10 ARS questions into each lecture to focus students' attention and to provide feedback on students' comprehension of the material. The questions were designed as conceptual questions and focused on the different key concepts of the ongoing lecture. Each question was administered directly following the lecture coverage of a particular key concept. When a question was presented, the students had 2-3 minutes to discuss possible solutions with their immediate neighbors, come to a conclusion, and individually submit their answers. Afterwards, the correct answer was displayed and explained by the instructor. Therefore, a total of 3-4 minutes was spent on each question. Then the instructor moved on to the next lecture topic.

Utilizing the ARS served as a tool for the instructor to gauge the pace of each lecture and to add additional in-class examples and explanations when indicated. Because the students responded to questions with their own mobile devices and were not restricted by the limited functionality of physical clickers, a variety of question types could be utilized, although most questions were in multiple-choice and multiple-answer format. Depending on the question, 4-6 answer choices were presented. Occasionally, fill-in-the-blank, sorting/matching, free-response and hot-spot (click-on-target) questions (**Figure 3**) were administered. A breakdown of questions by type used throughout the course is shown in **Table 1**. The lecture material presented in each class was simultaneously broadcast to the students' mobile devices.

Data collection and analysis

TABLE 1
Type and Number of ARS Questions Administered Throughout the Course

Question Type	Number of Questions
Multiple-choice	120
Multiple-answer	40
Fill-in-the-blank	20
Sorting/matching	10
Free-response	10
Hot-spot (click-on-target)	10

ARS = audience response system

At the conclusion of the course, prior to releasing course grades, the instructor administered an anonymous survey to receive the students' input and evaluate their experiences using the Top Hat ARS. The survey questions are shown in **Table 2**. In addition, the instructor identified a total of 36 questions that had been administered in the cumulative final examinations of the optics course during the current academic year as well as during the previous academic year. In that previous year, 85 students were enrolled in the course, and no ARS was utilized. The placement of the course within the academic year, its duration and the content covered were the same in both years. In addition, the same instructor taught the courses. The only difference was the utilization of the ARS.

Table 1. [Click to enlarge](#)

A retrospective cohort analysis was used to compare the scores per question between the two student groups. After the Kolmogorov-Smirnov normality test was passed, a two-tailed paired samples t-test was performed to compare the average scores for each question to the scores from the prior academic year. A P-value less than 0.05 was considered to be statistically significant. Prism 7 software (GraphPad Software, San Diego, Calif.) was used for conducting the statistical analysis. The project was approved by Western University of Health Sciences' Institutional Review Board (19/RFD/023 X19/IRB/061).

Results

Seventy-three first-year optometry students participated in the survey. Of those, 94.5% favored an instructional strategy that allowed using an ARS during lectures; 93.2% reported that the ARS questions helped them to maintain attention during class; 87.7% of the students recommended using an ARS in most or all lectures; and 94.5% preferred 3-10 ARS questions during a 90-minute lecture. Although a range of question types was available, 96% of the students in this cohort preferred multiple-choice questions. The detailed student response distributions to the survey questions are depicted in **Figure 4**.

TABLE 2

Survey Questions Regarding Experience with ARS Throughout the Course

Questions	Response Options
Q1: Do you prefer lecture with or without using an ARS?	(A) With ARS (B) Without ARS
Q2: Using an ARS during class helps maintain my attention.	(A) Yes (B) No
Q3: How often should an ARS be used?	(A) All lectures (B) Most lectures (C) Very few lectures (D) Only the most difficult lectures (E) Never
Q4: During a 90-minute lecture, how many ARS questions should be administered?	(A) More than 10 (B) 7 to 10 (C) 3 to 6 (D) 1 to 2 (E) None
Q5: What, if any, is your least favorite aspect of using the ARS?	(A) I like everything about the ARS (no negatives) (B) Cost too high (C) Too much noise (D) Too much distraction (E) Does not enhance my learning
Q6: Which question type do you prefer when using an ARS?	(A) Multiple-choice (B) Multiple-answer (C) Fill in the blank (D) Scoring/Matching (E) Free-response (F) Hot-spot (click-on-target)

ARS = audience response system

Table 2. [Click to enlarge](#)

When examination scores of 36 questions administered in different cohorts enrolled in the same course in two successive years were analyzed, the group working with the Top Hat ARS during lectures showed a small, but statistically significant, mean improvement of 3.7% (SD 9.3), from 83.6% (SD 15.0) to 87.3% (SD 11.1). (P-value 0.021, paired-samples t-test, two-tailed, t = 2.41). In addition, no questions scored below 50%, whereas two questions scored lower than 50% when no ARS was used. The number of questions scoring 90% or higher increased from 21 without the use of an ARS to 26 with the use of an ARS. This indicated that academically strong as well as academically weaker students benefited from the intervention. The distribution of the scores is shown in **Figure 5**.

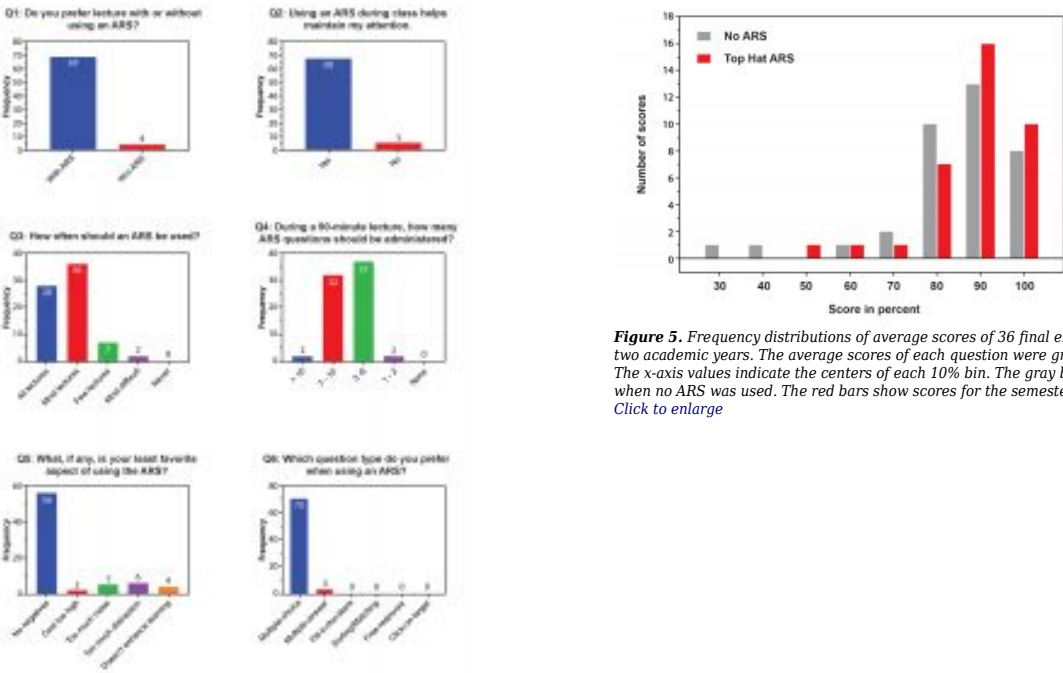


Figure 4. Distributions of student responses to survey questions regarding their experience with and suggestions for using the Top Hat ARS throughout the course. [Click to enlarge](#)

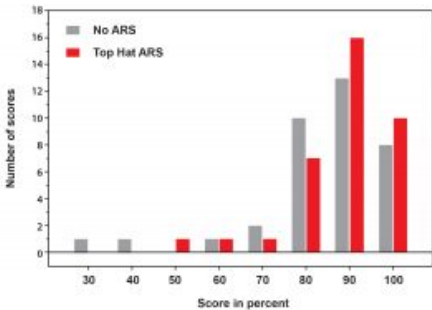


Figure 5. Frequency distributions of average scores of 36 final examination items in the same course in two academic years. The average scores of each question were grouped into eight bins, starting at 25%. The x-axis values indicate the centers of each 10% bin. The gray bars show scores for the semester when no ARS was used. The red bars show scores for the semester when the Top Hat ARS was used. [Click to enlarge](#)

Discussion

The instructor utilized the web-based Top Hat ARS in conjunction with small-group discussions during face-to-face lectures of a semester-long first-year geometrical and ophthalmic optics course. The goals were to improve student motivation and attention during lectures; to provide immediate feedback to the instructor concerning student comprehension; and to improve student performance on the cumulative final course examination. Based on student feedback, the instructor's experiences throughout the course, and improved examination scores compared to the prior academic year during which no ARS was utilized, the instructor believes the goals were met.

The students' feedback regarding the ARS was overwhelmingly positive, and most students believed that its use helped their in-class attention, which is one of the fundamental requirements for effective learning. This is supported by other studies, which reported that students find an ARS during lecture generally helpful and feel that it stimulates participation, engagement and interaction between students, and that it motivates them to learn.^{3,7,8,11-14,18,20-26} The students in this study recommended using 3-10 ARS questions during most or all 90-minute lectures. According to Premkumar and Coupal, one engagement question every 15-20 minutes should be administered to keep the attention of students during lecture, and a higher number of questions should be used if the purpose is formative assessment or review.¹⁰

Throughout the course, the administration and discussion of ARS questions took time and required careful planning of each lecture, assigning pre-lecture reading, and deciding on the types and number of ARS questions to be utilized. Active learning requires a high quality of participation, where students have an opportunity to interact with each other, the instructor and the lecture material.¹⁴ To allow a high quality of participation and to exercise the students' ability to think critically, the instructor emphasized higher-order ARS questions and implemented small-group discussions. In addition, the "safe environment" that the Top Hat ARS provided through the anonymity of its in-class responses gave students the ability to test their knowledge without fear of judgement. It is known that utilizing an ARS during lectures encourages the participation of otherwise reluctant or "shy" students.^{18,21}

Because course attendance was mandatory, using the ARS responses to track attendance served as an incentive for the students to engage in small-group discussions and to answer the questions. For courses without mandatory attendance, several studies have suggested associating a portion of the course grade with the use of an ARS to ensure a high level of participation.^{21,23,30} Throughout the course, utilizing ARS questions gave immediate feedback for the instructor to determine the level of understanding of the material by the students. This allowed further discussion and clarification of subjects if needed, and direction of each lecture accordingly. Even though multiple types of questions were presented throughout the semester, most students preferred multiple-choice questions. One possible reason is that most of the presented questions were multiple-choice and the students became accustomed to this format. Another reason might be that, from a technological standpoint, it is easier to respond to a multiple-choice question because it requires only selecting the answer choice. In addition, standardized tests primarily utilize multiple-choice questions, and students might have preferred this question style in order to become prepared for the course examinations. Furthermore, it is known that students perceive multiple-choice questions as assessing knowledge-based cognitive processing.³¹ Therefore, the instructor should assure that, regardless of the type of question, higher levels of intellectual skills and abilities such as analysis, application and comprehension are also evaluated when designing assessment questions.

On 36 examination items, the student cohort using the Top Hat ARS during class showed an improvement in average question score from 83.6 (SD 15.0) to 87.3 (SD 11.1). In addition, the standard deviation of distributed scores decreased, which indicated that students engaged with the material through the ARS questions and became overall more proficient in correctly answering comparable types of questions when presented on the examination. Even though there are mixed opinions in the literature, several other studies reported similar outcomes. For example, studies by Poulis et al., Schackow et al., Yourstone et al., Mayer et al. and Levesque et al. reported that students who used an electronic ARS showed significantly higher scores on quizzes and examinations compared with control groups that did not use an ARS.^{2,20,26-28}

Other studies did not always show an increase in test performance associated with the in-class use of an ARS, and several explanations have been discussed. Stoddard and Piquette reported that enhancing lectures by adding examination-style questions, and not necessarily a specific ARS technology itself, resulted in improved examination performance.²⁹ Crossgrove and Curran found that the additional introduction of an ARS did not result in improved test performance because active learning strategies were already implemented in a prior administration of the course.²⁴ In a study by Fitzpatrick et al., the authors found that the implementation of an ARS improved student performance in introductory level courses but not in senior-level courses, and suggested that students have mastered effective learning in senior-level courses.²⁵ Because the study reported here also showed improved student performance in an introductory level course, a future follow-up study on the same cohort in their advanced optics course may provide additional insights related to Fitzpatrick et al.'s suggestion.

In addition, the study reported here found that the number of questions scoring below 50% decreased from two without the use of an ARS to zero with the use of an ARS. The number of questions scoring 90% or greater increased from 21 without use of an ARS to 26 with use of an ARS. This implied that academically strong as well as academically weaker students benefited from the intervention. In particular, the improvement of very low scores indicated that the ARS activity helped to correct conceptual misunderstandings or misinterpretation of assessment questions. The improved examination performance could be an indication of students experiencing increased confidence or improved capacity for solving problems, effects which are linked to ongoing formative feedback during class.²⁴ Because this feedback can be efficiently delivered via the use of an ARS, it contributes to active learning.²⁶

Some challenges and limitations were experienced during this study. First, it was not ascertained whether students had previous experience with an ARS platform or if the ARS was challenging to use throughout the course. By the end of the semester, it became known that the students overall had a positive experience using the software. In addition, different cohorts of students from two successive academic years were compared. Even though there was little variation in the average academic strength of a student cohort, these were different groups of students. Content, duration and placement of the courses were similar, and the same instructor taught the courses; however, it is not possible to exactly replicate the same course experience in different years.

Despite these limitations, the study results suggested the Top Hat ARS was a valuable tool for keeping students engaged in lectures throughout the course and for facilitating better performance on graded examination questions. A variety of factors likely contributed to this improvement. First, the students were consistently stimulated to pay attention to the ongoing lecture and interact with the material when ARS questions were posed. Second, the small-group discussions provided input from the students' peers. Third, the correct answer for each ARS question was explained by the instructor before moving on to the next lecture topic. Fourth, having ARS questions in every lecture fostered the habit of problem-solving at the time of presentation.

Conclusion

The incorporation of an audience response system into face-to-face lectures can be a valuable teaching tool in facilitating active learning. It provides an opportunity to improve students' quality of analysis and discussion of lecture content, and at the same time gives immediate feedback to the course instructor. In addition, the ARS allows students the ability to test their knowledge without fear of judgement, and therefore encourages the participation of otherwise reluctant students. Because the implementation of the ARS occupies lecture time, it is necessary to carefully plan each session, assign pre-reading, and decide on the types and number of ARS questions to be utilized. To promote broad and sustained participation in ARS activities, an incentive may be provided, such as associating a portion of the course grade with the use of an ARS. To test the effects of utilizing an ARS in senior-level courses, future study considerations will be to evaluate its effects in a more advanced optics course.

Disclosure

The authors report no conflicts of interest related to this work.

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Effects of Course Design Decisions on Optometry Student Outcomes: Analysis of Lecture Synchronicity and Flipped-Model Learning, 2013-2016

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Introduction

With emerging pedagogical technologies and methods of content delivery, the face of education is changing rapidly. These changes are seen at all levels of education, from preschool to doctoral programs. It is an educator's duty to adapt to new technologies and methods to best serve students. But, is this embrace of technology always what is best for students? Do either the method of content delivery or the course model impact student success?

Though considerable research exists within optometric education and other education fields that evaluates the effects of innovative pedagogy, few investigators have considered how the effects of multiple simultaneous pedagogical innovations intersect. With the multitude of classroom innovations currently available, consideration of these *combined effects* is obviously needed. Among the pedagogical innovations recently embraced in optometric education is the flipped-classroom course organization, which attempts to improve student mastery and critical understanding of classroom material by using the lecture hall as a venue for active work.^{1,2} Lecture-capture technology has also been studied in optometric education. This technology provides both a backup copy of live lectures for review purposes and the flexibility to record lectures for viewing at a later time than that of the initial recording (i.e., *asynchronous content delivery*). The latter ability of lecture-capture technology has the potential to be quite useful for flipped-classroom organizations, as it permits facile movement of basic lecture-format material (e.g., statements of basic facts and concepts) out of the classroom for review prior to or after a classroom period, thus freeing classroom time for more active work.

The literature provides some context regarding these issues. For example, students tended to perform better on assessments of very difficult concepts when taught in a live lecture format rather than an asynchronous or online format.^{1,3} In courses that had asynchronously presented *online learning modules* (OLMs), students tended to perform better on short-term memory assessments (i.e., weekly quizzes) than those students who did not participate in OLMs (i.e., live lecture only). The OLMs did have interactive features in addition to recorded narratives and videos. However, there was no difference in performance on long-term memory assessments (i.e., Midterm and Final Examinations) between students who engaged with OLMs vs. those who attended only live lecture.⁴

This observation is consistent with further studies that explore how faculty presence affects online or flipped-model courses. Common themes in these studies are that a strong faculty presence in such settings increases student cognitive engagement and, furthermore, students *expect* a strong faculty presence in these courses.^{3,5,6} Smaller class sizes also correlated with increased student engagement, which was positively correlated with course grades.⁵ When both students and the faculty member were engaged in a course, students had a more positive experience with the course overall.

Interestingly, a common theme regarding lecture-capture technology and flipped-model classrooms is that while they offer significant benefits, they cannot and should not replace live lecture.^{4, 6-10,11} Some of the positive attributes of flipped-classroom models and lecture-capture technology from a student perspective are that they allow students access to lecture material whenever and wherever they need it, which is extremely important to students with busy academic and non-academic schedules.^{2,7} These models also permit self-pacing of instruction and allow presentation of material in multiple modalities.^{2,4} Research indicates that all students benefit from multiple modalities of content delivery (e.g., live lecture, recorded lecture, online assignments, etc.) and that some may need to spend more or less time with the material before mastering it. Learning is not a "one-size-fits-all" activity, and the availability of multiple modalities of delivery is often more effective than a single modality. However, a student must have an intrinsic desire to learn to succeed in the flipped classroom, so these models do not tend to work well for students who typically come to class unprepared.²

Faculty opinions toward flipped-classroom course organization and lecture-capture software tend to be more negative than those of students. Particularly poor are faculty opinions of lecture capture as a supplement to live lecture courses. The largest concern is that attendance in live lecture formats would decrease if lectures are recorded and made available for on-demand viewing. However, one study found that the availability of online lecture material did not decrease attendance compared to restriction of online lectures.¹⁰ Students reported that they predominately used online lecture material to catch up on lectures

that were missed. The most common reason that students reported missing live lectures was because of conflicts with assignments in other courses.⁷

Comparisons of overall course performance between live lecture and asynchronous delivery courses have yielded conflicting outcomes. Some studies found that students who attended live lectures performed better than students who relied on online lecture material only.^{7,8} One of these studies also found that weaker students were more likely to miss live lecture periods and rely only on online lecture capture for content delivery, which may explain why those students were poorer performers.^{6,8} However, most studies have found that live lecture and asynchronous delivery have equivalent effects on student course performance.⁷⁻⁹ Some of these studies did not separate students who attended live lectures *and* used available online lectures, which may explain some of this discrepancy. In general, it seems a reasonable assumption that students who use all available resources will perform better than those who only use one.

One study explored the use of podcasts as an alternative to live lecture for optometry students.¹² Just more than half of the students indicated they had downloaded and listened to at least one podcast and were classified as listeners. The rest of the students did not listen to any podcasts and were classified as non-listeners. Most listeners stated they used the podcasts to “fill in gaps” and revisit material from the live lecture. The vast majority of listeners felt that the podcasts were valuable in increasing understanding of material (94.6%). Of non-listeners, the main reason they did not use the podcasts was a lack of familiarity with how to access the material (34.4%). When asked if podcasts would be a suitable replacement for live lectures, both listeners and non-listeners (85.7% and 83.9%) felt they would not be a suitable replacement.

Purpose of the Study

There are several studies investigating the effects on student outcome measures of flipped-classroom courses and lecture-capture technology use. However, apart from one, none of these studies specifically investigates optometric education. Also, none looks at the combined effects of implementing these two classroom innovations simultaneously.¹² Our study seeks to address these gaps by answering three research questions. First, do optometry students perform better on course assessments with live, in-person instruction as compared to asynchronous, distance instruction using lecture-capture technology (i.e., *differences in distance*)? Second, do optometry students perform better in a traditional, lecture-based educational format as compared to a flipped model that focuses more on textbook readings and assignments (i.e., *difference in model*)? Third, how do these differences in distance and in model affect optometry students’ academic performance when implemented simultaneously?

Methods and Results

Methods for this study were reviewed and approved by the Southern College of Optometry (SCO) and Ferris State University Institutional Research Boards on June 6, 2017 and June 29, 2017, respectively. A waiver of informed consent was obtained from the same bodies on June 27 and June 29 because the study involved only a retrospective analysis of existing academic records.

Data from subjects in the SCO and Michigan College of Optometry at Ferris State University (MCO) neuroscience courses (OPT 113 and OPTM 635, respectively) are included in this study. The data come from the course sections taught from Fall 2013 to Fall 2016. Due to differences in the curricular design of the two colleges, OPT 113 was taught during the first year of the SCO curriculum, while OPTM 635 was taught during the second year of the MCO curriculum. The Instructor of Record for the SCO neuroscience course recorded his lectures via the Tegrity lecture-capture software and made them available on the Tegrity web-based application to MCO students asynchronously. These lectures, as well as reading assignments, online assignments, examinations, quizzes and other course elements were shared so that the totality of the course material was the same for the SCO and MCO neuroscience courses. The lone exception to this practice was the last lecture of the semester, which routinely could not be recorded as normal due to the MCO Fall semester ending sooner than the SCO Fall semester. Thus, for most years, this lecture was specially recorded via Tegrity for the MCO class, while a live version of the lecture was presented to the SCO class afterwards. In 2016, this lecture was converted to a self-paced, mastery-model online learning assignment for all students.

Various professors at MCO acted as course liaisons, responsible for the administrative elements of the course. These professors did not perform content delivery, and were given a small amount of administrative workload for their time to act as course facilitators only. Three other elements differed between the two courses. The first was the lack of the Instructor of Record’s physical presence on the MCO campus. Second was the inclusion of a one-hour-per-week live recitation session, in which the Instructor of Record took questions and reviewed material with the MCO students via live video-conferencing, designed to replace in-person office hours. The third was the examination formats, which were given on paper and through the laptop computer-based ExamSoft platform for the SCO classes, and through the infrared remote-controlled Turning Point response system for the MCO classes. Though these evaluation methods had certain interfacial and aesthetic differences, other

elements of the examinations, including content, time allotted and testing environment, were similar between sites. Aside from these three differences, students enrolled in the SCO and MCO courses had access to the exact same content and were evaluated using the exact same assessment items.

Asynchronous vs. synchronous course presentation (School)

There were 678 students who completed either OPT 113 or OPTM 635 between 2013 and 2016 and were included as subjects in this study. The records of students who withdrew from the course mid-term were not included among the subjects. The independent sorting variable — named *School* — was defined by whether a student took the live class (n_{live}) or the asynchronous class (n_{asyn}). See the notes with individual tables for sample sizes.

Traditional vs. flipped classroom (Type)

For the 2013 and 2014 course administrations, the majority of the neuroscience course material was delivered as lecture, with suggested readings in the course textbook for enhancement, i.e., a traditional model. For the 2015 and 2016 administrations of the neuroscience courses, the Instructor of Record adjusted the course material (or, in common parlance, “flipped the classroom”) to make the material presentation more student-driven. Under this new course organization, the number of lectures was reduced by half. Lectures that remained were designed to enhance and expand the foundational knowledge the students had already obtained from their preparatory work. Practically, this meant that lectures contained complex and optometry-related course material but few factual or conceptual definitions. Basic course material was introduced via assigned textbook readings (for which students were given course time off) and reinforced through online learning modules developed by the Instructor of Record. Though it is beyond the scope of this report to describe these proprietary modules in detail, suffice it to say they followed the self-paced, mastery model of presentation and focused on detailed neuroanatomy subjects (specifically, cranial nerve anatomy and function, Horner’s syndrome, and — in the 2016 course administration — ascending and descending central pathways). Students were required to complete textbook readings over the material contained in the modules prior to completing the modules, which expanded and reinforced the textbook information. Internal studies indicated that completion of these modules led to effective knowledge transfer and, compared to traditional lectures, may have improved student performance on related examination items.^{13,14}

The flipped-model course organization was used for the 2015 and 2016 administrations of the courses. Thus, in addition to the *School* variable, the students who completed one of the neuroscience courses from 2013 to 2016 can be further classified by *Type*: whether they completed the lecture-heavy, traditional course (n_{trad}) or the reading-driven, flipped course (n_{flip}).

Academic variables

Existing academic records for subjects were obtained from the files of the Instructor of Record of OPT 113 and OPTM 635, while subjects’ Optometry Admission Test (OAT) scores were obtained from the offices of Academic Affairs of SCO and MCO. OAT academic average (OATAA), OAT total science (OATTS), OAT subsection scores (OATBIO, OATGC, OATOC, OATPHYS, OATRC and OATQR), Midterm Examination Grades (*Mid1* and *Mid2*), Final Examination Grades (*FinalEx*) and Final Course Grades (*Course%*) were gleaned from these records and sorted by the subjects’ school-issued identification numbers. Throughout this paper, these are defined as *academic variables*.

Student records were randomized using a List Randomizer tool (<https://www.random.org/>) and assigned a unique depersonalized ID number based on that random order (“*ID Number*”). These data were compiled in a spreadsheet and imported into IBM SPSS 24 for analysis.

Research question 1

The first research question asked whether optometry students achieved similar grades from live instruction and asynchronous instruction in a neuroscience course. To evaluate this, we compared the means, medians and distributions of academic variables across different values for *School*.

Descriptive statistics and normality assumptions for the *School* value distributions across different academic variables are found in **Tables 1 and 2**.

Independent-samples Student’s *t*-tests were performed on the parametric distributions across different values of *School*. Due to the uneven sample sizes between live and asynchronous groups, effect size was determined with the Hedge’s *g* method. Several non-parametric tests were performed on the non-parametric distributions, specifically the independent-samples median test, which compares medians from different populations, and the independent-samples Mann-Whitney *U* and independent-samples Kolmogorov-Smirnoff tests, which both evaluate the distributions from which samples are drawn.

Results

Full results of these analyses are presented in **Table 3**. Students in the live instruction sample had significantly higher *OATAA*, *OATTS*, *OATRS*, *OATBIO* and *FinalEx* scores ($\alpha < .05$); though students in the asynchronous sample had significantly higher scores on *Mid1* and *Mid2* ($\alpha < .05$). Differences between live and asynchronous sample students in other academic variables were not significant.

TABLE 1

Descriptive Statistics of Distributions for Different Values of School by Academic Variable

Academic variable name	Mean	Mean _{live} - Mean _{asyn}	Median	Median _{live} - Median _{asyn}	Standard deviation
<i>OATAA</i> _{live}	327.43		320		19.528
<i>OATAA</i> _{asyn}	323.11	-4.32	320	0	17.491
<i>OATTS</i> _{live}	321.98		320		26.912
<i>OATTS</i> _{asyn}	316.76	-5.22	320	0	22.322
<i>OATQR</i> _{live}	324.97		320		29.912
<i>OATQR</i> _{asyn}	321.22	-3.75	320	0	30.280
<i>OATRC</i> _{live}	352.10		350		30.883
<i>OATRC</i> _{asyn}	344.05	-8.05	340	-10	34.441
<i>OATPHYS</i> _{live}	300.95		300		29.852
<i>OATPHYS</i> _{asyn}	296.08	-4.87	295	-5	27.196
<i>OATBIO</i> _{live}	332.81		330		31.795
<i>OATBIO</i> _{asyn}	324.12	-8.69	325	-5	30.705
<i>OATGC</i> _{live}	329.28		320		32.710
<i>OATGC</i> _{asyn}	326.19	-3.09	330	-10	27.517
<i>OATDC</i> _{live}	318.85		310		35.781
<i>OATDC</i> _{asyn}	318.85	0.00	310	0	32.294
<i>Mid1</i> _{live}	85.34		87.5		10.899
<i>Mid1</i> _{asyn}	88.48	-3.14	90	-2.5	7.707
<i>Mid2</i> _{live}	81.96		83		10.593
<i>Mid2</i> _{asyn}	88.02	-6.04	89.3	-6.3	11.057
<i>FinalEx</i> _{live}	81.58		82.91		10.736
<i>FinalEx</i> _{asyn}	78.72	-2.86	79.18	-3.73	9.806
<i>Course%</i> _{live}	86.20		86.45		7.115
<i>Course%</i> _{asyn}	86.10	0.10	86.46	-0.03	6.726

Note: $n_{live} = 529$ and $n_{asyn} = 148$.

Table 1. [Click to enlarge](#)

TABLE 2

Normality of Academic Variables by Different Values of School

Academic variable name	M	Shapiro-Wilk Test for normality	Sig.
<i>OATAA</i> _{live}	0.912		**
<i>OATAA</i> _{asyn}	0.057		**
<i>OATTS</i> _{live}	0.029		**
<i>OATTS</i> _{asyn}	0.960		**
<i>OATQR</i> _{live}	0.915		**
<i>OATQR</i> _{asyn}	0.984		.059
<i>OATRC</i> _{live}	0.982		**
<i>OATRC</i> _{asyn}	0.959		**
<i>OATPHYS</i> _{live}	0.968		**
<i>OATPHYS</i> _{asyn}	0.971		.003*
<i>OATBIO</i> _{live}	0.978		**
<i>OATBIO</i> _{asyn}	0.965		.106
<i>OATGC</i> _{live}	0.967		**
<i>OATGC</i> _{asyn}	0.978		.019*
<i>OATDC</i> _{live}	0.980		**
<i>OATDC</i> _{asyn}	0.960		.026*
<i>Mid1</i> _{live}	0.951		**
<i>Mid1</i> _{asyn}	0.927		**
<i>Mid2</i> _{live}	0.983		**
<i>Mid2</i> _{asyn}	0.969		.263
<i>FinalEx</i> _{live}	0.971		**
<i>FinalEx</i> _{asyn}	0.962		.594
<i>Course%</i> _{live}	0.986		**
<i>Course%</i> _{asyn}	0.983		.059

Note: $n_{live} = 529$ and $n_{asyn} = 148$. * indicates the finding is significant at the .05 level. ** indicates the finding is significant at <.001.

Table 2. [Click to enlarge](#)

TABLE 3

Significance of Academic Variables Comparisons Across Different Values of School

Comparison name	Test name(s) and test statistic value(s)	Sig.	Effect size
Parametric comparisons			
<i>OATAA</i>	Independent samples Student's <i>t</i>	.008*	.236
<i>OATTS</i>		.042*	.174
<i>OATRC</i>		.008*	.254
<i>OATPHYS</i>		.067	.186
<i>OATGC</i>		.033	.203
<i>OATDC</i>		.964	0
<i>Mid1</i>		.311	.311
Non-parametric comparisons			
<i>OATQR</i>	Independent samples median	.921	.9802
	Independent samples Mann-Whitney <i>U</i>	.407	—
	Independent samples Kolmogorov-Smirnov	.913	—
<i>OATBIO</i>	Independent samples median	.038*	.2592
	Independent samples Mann-Whitney <i>U</i>	.011*	—
	Independent samples Kolmogorov-Smirnov	.164	—
<i>Mid2</i>	Independent samples median	**	.5502
	Independent samples Mann-Whitney <i>U</i>	**	—
	Independent samples Kolmogorov-Smirnov	**	—
<i>FinalEx</i>	Independent samples median	.003*	.2712
	Independent samples Mann-Whitney <i>U</i>	.001*	—
	Independent samples Kolmogorov-Smirnov	.003*	—
<i>Course%</i>	Independent samples median	.928	.9142
	Independent samples Mann-Whitney <i>U</i>	.761	—
	Independent samples Kolmogorov-Smirnov	.908	—

Note: $n_{live} = 529$ and $n_{asyn} = 148$. * indicates the finding is significant at the .05 level. ** indicates the finding is significant at <.001. (For non-parametric testing, no test statistic value can be obtained. *d* is a non-adjusted parametric effect size value, which may be of limited benefit in evaluating the true effect size of non-parametric results.)

Table 3. [Click to enlarge](#)

Research question 2

The second research question asked whether optometry students achieved similar grades in a traditional model (n_{trad}) and a flipped model (n_{flip}) in a neuroscience course. To evaluate this, we compared the means, medians and distributions of our academic variables across different values for *Type*. Descriptive statistics and normality assumptions across different academic variables are found in **Tables 4 and 5**.

Independent-samples Student's *t*-tests were performed on all distributions across different values of *Type*, except for *Mid2*, which had a non-parametric element. The similar sample sizes between the traditional and flipped samples allowed effect size to be calculated using Cohen's *d* statistic, except in cases where the standard deviations of the two samples' performances were considerably different (defined here as >3.0). In those cases, Gates' Δ was used. The non-parametric independent-samples median, Mann-Whitney *U* and Kolmogorov-Smirnov tests were performed on the non-parametric *Mid2* distribution.

Results

Full results of these statistical analyses are presented in **Table 6**. There are significant differences ($\alpha < .05$) between traditional-model and flipped-model students in *OATAA*, *OATQR* and *OATGC* scores, in *Mid1* and *FinalEx* scores, and Kolmogorov-Smirnov testing for *Mid2*. Differences between traditional-model and flipped-model students across other academic variables were not significant.

TABLE 4
Descriptive Statistics of Distributions for Different Values of Type by Academic Variable

Academic variable name	Mean	Mean _{live}	Median	Median _{live}	Standard deviation
GA7AA _{live}	324.90		320		19.439
GA7AA _{trad}	326.04	-3.14	320	0	18.805
GA7TS _{live}	316.33		310		26.932
GA7TS _{trad}	321.87	-3.54	320	-10	25.936
GA7DR _{live}	319.16		320	30.405	
GA7DR _{trad}	329.04	-9.88	320	-10	26.838
GA7RC _{live}	350.03		350	31.439	
GA7RC _{trad}	350.94	-0.91	350	0	32.227
GA7PHYS _{live}	296.49		290	29.919	
GA7PHYS _{trad}	301.29	-2.84	300	-10	26.840
GA7BO _{live}	329.34		330	32.329	
GA7BO _{trad}	332.13	-2.79	330	0	31.125
GA7OC _{live}	326.51		320	33.095	
GA7OC _{trad}	321.96	-5.45	320	-10	29.926
GA7DC _{live}	319.16		320	36.949	
GA7DC _{trad}	317.95	1.21	310	10	33.390
Mid1 _{live}	88.39		90	9.910	
Mid1 _{trad}	83.71	4.68	85	5	9.920
Mid2 _{live}	82.58		83.75	9.751	
Mid2 _{trad}	84.01	-1.43	84.91	-1.16	12.270
FinalEx _{live}	83.70		83.93	8.930	
FinalEx _{trad}	78.27	5.43	78.16	5.75	11.400
Course% _{live}	85.60		86.16	6.746	
Course% _{trad}	86.45	-0.45	87.02	-0.84	7.263

Note: $n_{live} = 335$ and $n_{trad} = 342$.

[Table 4. Click to enlarge](#)

TABLE 5
Normality of Academic Variables by Different Values of Type

Academic variable name	W	Sig.
GA7AA _{live}	0.918	**
GA7AA _{trad}	0.923	**
GA7TS _{live}	0.926	**
GA7TS _{trad}	0.933	**
GA7DR _{live}	0.981	**
GA7DR _{trad}	0.978	**
GA7RC _{live}	0.981	**
GA7RC _{trad}	0.962	**
GA7PHYS _{live}	0.966	**
GA7PHYS _{trad}	0.968	**
GA7BO _{live}	0.983	.001*
GA7BO _{trad}	0.976	**
GA7OC _{live}	0.964	**
GA7OC _{trad}	0.973	**
GA7DC _{live}	0.984	.001*
GA7DC _{trad}	0.974	**
Mid1 _{live}	0.794	**
Mid1 _{trad}	0.960	**
Mid2 _{live}	0.974	**
Mid2 _{trad}	0.960	.061
FinalEx _{live}	0.978	**
FinalEx _{trad}	0.986	.002*
Course% _{live}	0.984	.001*
Course% _{trad}	0.985	.001*

Note: $n_{live} = 335$ and $n_{trad} = 342$. * indicates the finding is significant at the .05 level. ** indicates the finding is significant at <.001.

[Table 5. Click to enlarge](#)

TABLE 6
Significance of Academic Variables Comparisons Across Different Values of Type

Comparison name	Test name(s) and test statistic value(s)	Sig.	Effect size
Parametric comparisons			
GA7AA	Independent samples Student's t		
GA7AA	-2.263	.024*	.164
GA7TS	-1.878	.061	.136
GA7DR	-4.405	**	.333
GA7RC	-0.309	.757	.019
GA7PHYS	-1.356	.176	.097
GA7BO	-1.223	.222	.088
GA7OC	-2.326	.020*	.165
GA7DC	0.581	.561	.049
Mid1	6.077	**	.472
FinalEx	6.912	**	.608
Course%	-1.102	.271	.078
Non-parametric comparisons			
Mid2	Independent samples median	.167	.1472
	Independent samples Mann-Whitney U	.079	—
	Independent samples Kolmogorov-Smirnov	.019*	—

Note: $n_{live} = 335$ and $n_{trad} = 342$. * indicates the finding is significant at the .05 level. ** indicates the finding is significant at <.001. t-For non-parametric testing, no test statistic value can be obtained. ϕ^2 is a non-adjusted parametric effect-size value, which may be of limited benefit in evaluating the true effect size of non-parametric results.

[Table 6. Click to enlarge](#)

Research question 3

Because both the *School* and *Type* variables affected the neuroscience courses during the same time period, any effect identified by answering research questions one and two could be caused by either *School*, *Type* or some combination of the two effects. To better understand the true causes of any detectable effect, the third research question explored how the interactions between live/asynchronous presentations and traditional/flipped models influenced neuroscience course grades among optometry students. To do this, we compared the means of *classroom* academic variables (i.e., *Mid1*, *Mid2*, *FinalEx* and *Course%*) across different values of both *School* and *Type* (i.e., $n_{live*trad}$, $n_{asyn*trad}$, $n_{live*flip}$ and $n_{asyn*flip}$) using analysis of variance (ANOVA) testing. Descriptive statistics for the combination *School/Type* distributions across classroom academic variables are found in **Table 7**. ANOVA testing assumes that samples are taken from a normally distributed population and that all study groups have equal population variance (i.e., homogeneity of variance). Results of this testing are found in **Tables 8 and 9**.

TABLE 7
Descriptive Statistics of Distributions for Different Values of School and Type Combinations by Classroom Academic Variable

Classroom academic variable name	School/Type combination	Mean	Standard deviation
Mid1	Live & traditional	88.18	10.614
	Asynchronous & traditional	89.17	6.612
	Live & flipped	82.63	10.018
	Asynchronous & flipped	87.81	8.642
Mid2	Live & traditional	82.29	9.850
	Asynchronous & traditional	83.62	9.379
	Live & flipped	81.73	11.304
	Asynchronous & flipped	92.31	12.106
FinalEx	Live & traditional	84.29	8.616
	Asynchronous & traditional	81.58	9.075
	Live & flipped	78.92	11.754
	Asynchronous & flipped	75.94	9.751
Course%	Live & traditional	86.30	6.775
	Asynchronous & traditional	84.47	6.482
	Live & flipped	86.16	7.464
	Asynchronous & flipped	87.67	6.616

Note: $n_{live*trad} = 262$; $n_{asyn*trad} = 73$; $n_{live*flip} = 268$; and $n_{asyn*flip} = 75$.

[Table 7. Click to enlarge](#)

TABLE 8
Normality of Classroom Academic Variables by Different Values of School/Type Combinations

Variable name	W	Sig.
Mid1 _{live*trad}	0.961	**
Mid1 _{asyn*trad}	0.916	**
Mid1 _{live*flip}	0.964	**
Mid1 _{asyn*flip}	0.930	**
Mid2 _{live*trad}	0.974	**
Mid2 _{asyn*trad}	0.960	.000*
Mid2 _{live*flip}	0.987	.014*
Mid2 _{asyn*flip}	0.956	.011*
FinalEx _{live*trad}	0.968	**
FinalEx _{asyn*trad}	0.977	.211
FinalEx _{live*flip}	0.982	.002*
FinalEx _{asyn*flip}	0.980	.275
Course% _{live*trad}	0.979	.001*
Course% _{asyn*trad}	0.980	.267
Course% _{live*flip}	0.987	.018*
Course% _{asyn*flip}	0.980	.019*

Note: $n_{live*trad} = 262$; $n_{asyn*trad} = 73$; $n_{live*flip} = 268$; and $n_{asyn*flip} = 75$. * indicates the finding is significant at the .05 level. ** indicates the finding is significant at <.001.

[Table 8. Click to enlarge](#)

TABLE 9
Homogeneity of Variance of Classroom Academic Variables Across Different groups of School, Type, and School/Type Combinations

Classroom academic variable name	Levene's Test of equality of error variances	W	Sig.
Mid1		4.663	.003*
Mid2		1.790	.148
FinalEx		9.635	**
Course%		2.371	.069

Note: $n_{live*trad} = 262$; $n_{asyn*trad} = 73$; $n_{live*flip} = 268$; and $n_{asyn*flip} = 75$. Significant findings imply a lack of homogeneity of variance. * indicates the finding is significant at the .05 level. ** indicates the finding is significant at <.001.

[Table 9. Click to enlarge](#)

Mid2 met both the assumption of normality and the assumption of homogeneity of variance, and thus standard ANOVA was run to analyze this academic variable. The *Course%* classroom variable failed to meet the assumption of normality only, so standard ANOVA was run with the understanding that results should be carefully applied because the effect of non-parametric distributions upon the type 1 error rate is minimal. For those variables that failed to demonstrate homogeneity of variance only (i.e., *Mid1* and *FinalEx*), Welch's ANOVA test was run, which ignores the effect of variance in return for reduced discrimination.

Post-hoc testing

Because ANOVA and Welch's ANOVA only report whether a difference exists or not, post-hoc testing is used to understand the implications of a rejection of the null hypothesis. We used Tukey's method of post-hoc analysis on all significant findings to identify the pairs of means that differed significantly and those that did not (i.e., *homogeneous subsets*). Effect sizes for the

ANOVA and Welch's ANOVA results were determined by calculating η^2 for *School*, *Type*, *School*Type* and statistical error (an SPSS-determined value) for each of the four classroom academic variables.

Results

TABLE 10
Classroom Academic Variables Comparison
Combinations of School/Type

Test name	Test value
Welsh's ANOVA	25.11
ANOVA	21.78
Welsh's ANOVA	21.02
ANOVA	6.691

$n_{\text{live*Type}} = 268$, and $n_{\text{asyn*Type}} = 75$. * indicates the difference is significant at $p < .001$.

Table 10.

[Click to enlarge](#)

TABLE 11
Classroom Academic Variables Comparison
Combinations of School/Type

School η^2	Type η^2
.027	.022
.040	.086
.078	.021
.006	*

f.

Table 11.

[Click to enlarge](#)

TABLE 12
Post-hoc testing results for the significant differences in classroom academic variables comparison across different combinations of School/Type

Classroom Academic Variable	Comparison (School/Type)	Mean Grade	Standard Deviation	Significance Level
Mid1	Live/Flipped (200)	83.63	10.11	*
	Asyn/Flipped (75)	87.81	10.11	*
	Live/Traditional (268)	86.89	10.11	*
	Asyn/Traditional (75)	88.47	10.11	*
Mid2	Live/Flipped (200)	81.73	10.11	*
	Asyn/Flipped (75)	83.29	10.11	*
	Live/Traditional (268)	83.63	10.11	*
	Asyn/Traditional (75)	85.21	10.11	*
FinalEx	Live/Flipped (200)	83.63	10.11	*
	Asyn/Flipped (75)	85.21	10.11	*
	Live/Traditional (268)	86.89	10.11	*
	Asyn/Traditional (75)	88.47	10.11	*
Course%	Live/Flipped (200)	84.47	10.11	*
	Asyn/Flipped (75)	86.05	10.11	*
	Live/Traditional (268)	86.89	10.11	*
	Asyn/Traditional (75)	88.47	10.11	*

Note: Post-hoc testing performed at Tukey HSD. * Significance level is .001.

Table 12.

[Click to enlarge](#)

The third research question investigated how the interactions between live/asynchronous presentations and lecture/flipped models influenced neuroscience course grades among optometry students. Full results of ANOVA and Welch's ANOVA tests are presented in **Table 10**. Significant differences at the $\alpha < .05$ level were found between different groups for *Mid1*, *Mid2*, *FinalEx* and *Course%*. Effect sizes are available in **Table 11**. Post-hoc testing results are available in **Table 12**.

Overall, the results showed:

1. Mean grade on *Mid1* was significantly lower for students who took the live, flipped-model course than for students in other groups
2. Mean grade on *Mid2* was significantly higher for students who took the asynchronous, flipped-model course than for students in other groups
3. Mean grade on *FinalEx* was significantly lower for students who took the asynchronous, flipped-model course compared to those who took the traditional course (live or asynchronous)
4. Mean grade on *FinalEx* was significantly higher for students who took the live, traditional-model course compared to those who took the flipped course (live or asynchronous)
5. Mean *Course%* was significantly lower for students who took the asynchronous, traditional-model course compared to those who took the asynchronous, flipped-model course

Discussion

Our findings are fairly consistent with the literature: In general, there is no significant difference in student neuroscience course grades between either traditional models and flipped models, or live and asynchronous delivery methods, though individual examination grades may vary significantly. This suggests the variations in performance found in this study are the result of factors that influence short-term performance — as measured by individual examinations — but not long-term mastery of knowledge over the course of a semester. Because material delivery methods and course organization models were course-wide changes in this study, it is unlikely these changes can satisfactorily explain the variance seen in individual examination scores. Also, η^2 effect size analyses for ANOVA testing of *School* and *Type* intersectional subsamples for *Mid1*, *Mid2*, *FinalEx* and *Course%* values indicated that the vast majority of the variance seen in these values across subsamples is due to error; that is, factors that were neither controlled for nor investigated by our study. Because most of the variance of individual examination scores was apparently caused by factors other than delivery method and teaching model, the discussion that follows is primarily concerned with possible influences on short-term student performance that are peripheral to our research questions.

Entering academic ability

Analysis of OAT academic averages across samples of *School* demonstrated that students in the live instruction sample had scored significantly higher than the students in the asynchronous sample. Analysis of OAT subsection scores showed a similar pattern: live-instruction-sample students had scored higher than asynchronous-instruction-sample students on all OAT subsections (either significantly or insignificantly so).

A similar analysis of OAT academic averages across samples of *Type* show that students who were in the flipped classroom sample had scored significantly higher than students who were in the traditional sample. Likewise, OAT subsection scores (except for the subsection score in organic chemistry) showed significantly or insignificantly higher performances by students who would eventually enter the flipped sample compared to those who would enter the traditional sample.

These variations between the OAT scores and subscores of *School* and *Type* samples are explained by initial differences in admissions standards and applicant pool quality between the two institutions at the beginning of the study period, as well as increases in those same admissions standards and applicant pool quality over the four-year duration of the study. The larger question raised by the significant differences in OAT scores and subscores between samples is whether the studied populations are in fact comparable, or whether their variable OAT performances provide evidence of a considerable difference in entering academic ability.

Based on the results of the study it seems that — if there is a difference between samples — such differences in entering academic ability as measured by OAT did not seem to correlate with performance on individual examinations or course grades. OAT performances would predict that the live delivery, flipped-model sample would have the best academic outcomes, when in fact this subsample showed no significant difference between several other groups in performance on all academic variables.

Effects of optometry college enrollment duration and familiarity with material

Students who received asynchronous content delivery performed better than those who received live content delivery on both *Mid1* and *Mid2*. The effect size for *Mid1* indicates this was a moderate-strength difference, which may be due to the facts that MCO students in OPTM 635 (asynchronous sample) were second-year optometry students, while SCO students in OPT 113 (live sample) were first-year, and in fact first-semester, optometry students. MCO students had also been exposed to some neuroanatomy material previously in their first-year general anatomy and physiology and ocular anatomy courses, so that portions of the content featured in both Midterms was “review” for the MCO students. We believe the additional year in optometry college and greater familiarity with some of the course material made the students in the asynchronous sample more academically mature and thus better-suited to succeed on assessments than those in the live sample.

Mid2 in particular showed a large discrepancy in scores between the two samples of *School* with a resultant medium-to-large effect size, greater than that of *Mid1*, though the non-parametric nature of the *Mid2* distribution makes Cohen’s effect size analysis somewhat inaccurate. What effect is actually present between samples of *School* on *Mid2* may stem in particular from the previously discussed “review” that MCO students enjoyed because asynchronous sample students had learned about cranial nerves in the aforementioned two courses completed during their first years in optometry college, as well as in their concurrently taught optometric procedures course in their second-year curriculum. Because cranial nerve anatomy and assessment was a major portion of the *Mid2* Examination (accounting for approximately 55% of examination items), it is likely asynchronous sample students found a majority of questions on *Mid2* to be more familiar than did live sample students, while there were no reviewed subjects that constituted such a large portion of the assessment items on either *Mid1* or *FinalEx*. This idea of having a higher baseline of knowledge as an explanation for differences in performance has been hypothesized in other

studies.¹⁵

Final examination study strategies

Though students in the asynchronous sample performed significantly better on Midterm Examinations, live sample students performed significantly better on the *FinalEx*, resulting in no significant difference in Final Course Grade between the two samples. This inverse relationship between Midterm performance and *FinalEx* performance is probably not reflective of a true difference between the samples, but rather a difference in study strategies: students who entered the *FinalEx* having performed better on the Midterm Examinations likely prepared differently than those who were in a more precarious position.

Effects of reinforcement assignments on the flipped classroom

Across values of *Type*, students in the traditional sample performed better on *Mid1* (with a moderate effect size) and the *FinalEx* (with a strong effect size), while students in the flipped sample performed statistically the same as traditional students on *Mid2* and in their Final Course Grades.

The effect of content reinforcement may explain part of these differences. In the flipped model, the majority of the material assessed on all examinations was introduced through textbook readings. No learning modules were assigned to reinforce *Mid1* material. In contrast, *Mid2* material was reinforced by two online mastery-model learning modules, which together covered more than 60% of the *Mid2* assessment items. *FinalEx* material included one reinforcing learning module for the flipped sample, covering less than 10% of the material assessed by the *FinalEx*. The literature suggests that the more students practice retrieving material from memory, the better they learn the material, particularly when the practice sessions are spaced out in time from one another.^{4,16} That students were assigned an active, self-assessing method to retrieve and reinforce material first learned days prior may explain the difference in scores.

Our findings suggest that flipping the classroom so that the majority of material is introduced by student-directed activities may actually be less effective in terms of student learning outcomes than the traditional lecture model, in the absence of reinforcing assignments. However, with reinforcing assignments, academic outcomes in flipped-classroom models approach and may exceed those of traditional lecture courses. Thus, more rigorously designed flipped-model schemes that include regular summative assessment of assigned readings and classroom-introduced materials are to be preferred to a more *laissez-faire* approach.

It is not clear from this study whether the use of reinforcing assignments would improve academic performance in a traditional lecture setting, where material is introduced primarily from lectures rather than textbooks. Cognitive learning science seems to indicate that carefully designed reinforcing activities should improve learning of material regardless of its mode of presentation, but whether reinforcement works better in traditional or flipped-model courses remains an open question.^{4,16}

Effects of School combined with effects of Type

Though we studied the interaction between differences in material delivery and course model on neuroscience grades, it is difficult to draw implications from the extensive testing done on the intersectional subsamples of *School* and *Type* variables, for the significant findings do not seem to tell a consistent story. As stated above, effect size analyses indicated that the majority of the variance found in classroom academic variables between subsamples were caused by factors that were not controlled or investigated by our study.

The subsample of students who received live, flipped-model instruction scored most poorly on both semester examinations (though, only the performance on *Mid1* was significantly worse). There does not appear to be an obvious explanation for this and it is likely incidental.

FinalEx Grades for students in the asynchronous, flipped-model subsample were significantly lower than those of students who received traditional classroom instruction (regardless of live or asynchronous material delivery). Some of the effect could be due to the asynchronous/flipped sample's exceptional performance on *Mid2* (see below), which reduced the importance of the *FinalEx* toward the sample's Final Course Grades.

Building mental maps to reduce cognitive load

The subsample of students who specifically received flipped-style instruction asynchronously dramatically outperformed all other subsamples on *Mid2* (i.e., nearly 9% higher average grades than the next nearest group) and earned significantly higher Final Course Grades than students in traditional course models. This subsection of students benefited from both reinforcing learning modules and relatively greater maturity and experience with neuroanatomical material, and saw substantial

improvement in examination scores compared to student samples that benefitted from only one — or none — of these effects (i.e., when $Mid2_{live*trad}$ was compared to $Mid2_{live*flip}$ or $Mid2_{live*trad}$ to $Mid2_{asyn*trad}$). For these latter cases, the effects on $Mid2$ scores were less than 1% for each comparison. It may be, therefore, that the interaction between previous experience and the use of reinforcing learning modules is not merely additive but multiplicative. Though one hesitates to press the possibility of exponential effects too far based on one comparison, the positive potential of such an effect certainly invites additional investigation.

Cognitively, such a multiplicative effect can be explained by the mental map concept, which states that fluency in a particular complex skill (in this case, clinical assessment of cranial nerves) is based on the construction and refinement of a high-quality mental map of that material within a student's long-term memory. For complex actions like clinical cranial nerve assessment, the many facts, concepts and deductions needed to arrive at a correct diagnosis can be cognitively exhausting for a novice. Each step must be intentionally and consciously recalled, implemented and assessed in its correct order. The potential for forgetting a step or making a simple mistake under such levels of cognitive load is high.

With repeated, high-quality practice, however, complex processes are automatized, as the mind builds a mental map that includes all the discrete elements of the process in one whole. Thus, for the student whose practice has moved her from novice to intermediate, performing cranial nerve assessment is a simpler process, involving mere activation of the mental map she has already built. The cognitive load is lower because there are fewer discrete parts to attend to, and the potential for error is lessened. The implication is that programmed reinforcement of previously learned and recently relearned material, by students who have a year's practice mastering complex clinical concepts, could shepherd the development of a sophisticated mental map in a way that simply does not occur in the absence of one or both of these elements.¹⁶

Conclusion

There do not appear to be significant differences in Final Course Grades between live and asynchronous content delivery methods, traditional and flipped-course models, or combination samples. However, mastery of discrete skills or areas of knowledge may be influenced by many factors external to this study, including assignment of reinforcing learning modules in addition to initial material presentation, and previous exposure to material in prior contexts. Combination of these two elements seems to produce a multiplying effect on retention and mastery, suggesting that repeated and varied practice is crucial for learning course material.

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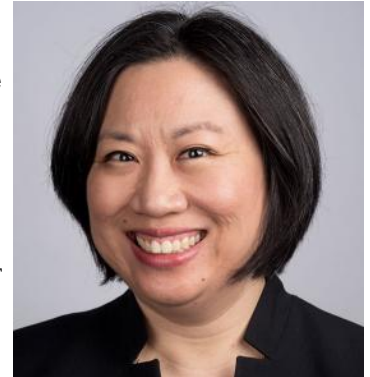
Industry News

| Optometric Education: Volume 46 Number 1 (Fall 2020)

Boosting Morale in an Optometry School During a Pandemic

Amy Roan Moy, OD, FAAO | Optometric Education: Volume 46 Number 1 (Fall 2020)

Investing time and energy into the mental health of our students, faculty and staff is more important than ever. It is especially difficult to do so when we cannot chat between lectures, stand too close in the same room, or see someone smile behind his or mask. A study from the Boston University School of Public Health showed that the prevalence of depression symptoms in U.S. adults more than tripled to 27.8% as of mid-April compared to 8.5% before the start of the COVID-19 pandemic.¹ Consider that these statistics were measured as the pandemic unfolded in the spring, and now we are heading into winter, when there is less daylight and less opportunity for outdoor activities. Much research has been done on the connection between student well-being and academic performance. Several studies of higher education and medical students have shown that students with higher levels of perceived stress have a greater risk for lower academic achievement.²



Amy Roan Moy, OD, FAAO

What We Can Do

Thinking of ways to boost morale while educating students virtually, or from behind multiple levels of personal protective equipment while socially distanced, can be challenging. While teaching a course on Zoom this summer, I found myself appreciating how the personalities of my students were gradually revealed in their little Zoom windows over the subsequent weeks. But by the time I felt as if I knew them better, the summer was over. Looking back, I wish we had spent more time in some get-to-know-you exercises early on because it may have fostered even livelier discussions in the long run.

Students need to feel like they belong and that they are part of a community. We all feel like this as human beings. This is a perfect time to use the cliché that “necessity breeds invention.” I spent some time thinking about ways to virtually foster relationships among students and staff, as well as how to build morale with so many limitations during the pandemic. I hope these lists help you to get your creative juices flowing.

Get-to-know-you ideas for virtual classrooms:

- **Artifact or photo of your life exercise:** I went through an artifact exercise as part of a leadership program with the Greater Boston Chamber of Commerce. Each person had two minutes (timed) in which to share an artifact that described something they were proud of. It was a really inspiring time of sharing, and we all felt we knew each other a bit more afterwards. Invite students to take a picture or show an artifact of something that represents their life or something of which they are proud.
- **Names on virtual platform:** Learning each person’s name really helps to personalize the experience. Consider having people change their screen names in the virtual platform to something interesting, such as listing their name and then their favorite food, musical group or favorite trip destination.
- **Experience-sharing:** Pick one person each week to share how they relate to a certain topic, such as the first time they saw retinal pathology, something they’ve learned in the past week about patient communication, something they’ve learned about cultural competency, etc.
- **Virtual chat:** Use the chat function to your advantage. Sometimes, there are too many people to get through for sharing what they think. Introduce a topic such as sharing what they think is most important about making a patient feel comfortable, and then have them write their answers in the chat so everyone can see the responses. This will foster a sense of group teamwork.
- **Be vulnerable:** When leaders show vulnerability and authenticity, they bring trust to the group, and others feel as if this is a safe space. Sharing about a time of anxiety or embarrassment that happened to you early in your career and how you have improved can go a long way towards reassuring students.
- **Theme of the day:** Invite the group to decide on a certain theme for the next meeting. This can be holiday-related, with everyone bringing their favorite autumn drink to the meeting. Another option is a summer in winter theme to help beat the winter blues.
- **Breakout rooms:** Smaller groups can help people to get to know each other. If your virtual platform has breakout rooms, consider naming a leader for each small group, and before focusing on the subject matter, ask them to share one thing that they are thankful/excited about/etc.
- **Stretch breaks:** If your class runs more than an hour, definitely provide breaks, but also consider a group stretch break if you

feel comfortable leading one. Or ask a student to pick a stretch and everyone can join in!

- Strategic homework: Assign projects that require students to work with each other outside of class, albeit virtually. This may mean case discussion, reporting on a certain element of eye exam procedures, doing a public health project, or submitting ideas for a poster presentation.

Ideas for fostering community, holiday spirit and fun outside of the classroom while maintaining masks and social distancing:

- Pumpkin or stocking decorating contest: Each staff member makes a pumpkin or stocking that represents another staff member (with rules set for appropriate themes). Team holiday tree decorating: Set up a tree centrally located so people can help to decorate and enjoy, socially distanced and taking turns, of course!
- Secret Santa: Exchange virtual e-gifts, or hold a virtual party in which gifts are sent ahead of time. Make sure to set a low cost limit to be inclusive of all involved.
- Thanksgiving or holiday “gratefulness tree”: Staff write what they are thankful for on a large vinyl decal tree in a common area. Check Pinterest for some great examples!
- Employee/student recognition program: If you have a secure chatting/messaging system within your site, consider fostering a culture of recognizing each other for positive actions big and small, such as assisting an elderly patient, going the extra mile to help a patient get glasses, etc.
- Regular or spontaneous individual check-ins with each staff member to monitor stress levels: Create a culture where it’s OK for someone to say they are feeling down that day.
- Comment board: Have a place (digital or in-person) for people to make suggestions. Follow-up at team meetings so people see follow-through in some way.
- Regular staff meetings: These virtual meetings can be used to discuss the small things that can add up, and to share outcomes so people can see the impact they have in their daily jobs.
- Unmasked faculty and staff pictures: In our school clinics, it can be difficult to identify doctors and students behind the masks. Consider putting up a board that shows pictures so that new student interns and patients will be able to see who’s who.
- Holiday food pantry contributions or gift card drive as a service project that requires teamwork: Check with your local food bank about its protocols during COVID-19.
- Virtual potluck in the clinical setting: We all miss potlucks! Avoid sharing common food items, but consider individually wrapped grab-and-go snacks. This allows people to enjoy the potluck atmosphere in a virtual meeting in their own spaces. Surprise gifts: Sometimes it’s just fun to receive an unexpected token of appreciation. Some ideas: mask ear savers, personal-sized hand sanitizer, individually wrapped snacks from a local bakery, a favorite candy, a small gift card.
- The sincere appreciation e-mail: You don’t need to spend money to show someone they are appreciated. A detailed e-mail telling a person what you specifically appreciate about him or her can make a day. A student will definitely appreciate a personal e-mail from a preceptor about how well he or she did with a patient or in a discussion that day.
- Online talent show: We have all held virtual town halls, but an online talent show could be fun, bring the community together, and highlight some exceptional (and brave!) individuals. This could be done live with Zoom polls for voting or by asking for video submissions and presenting them with live playbacks of their recordings.
- Set up a culture committee: A culture committee is made up of people from all parts of the organization who can advise leadership with well-formed ideas for improving the culture of the organization. Even if it’s temporary, a culture committee during the pandemic could be dedicated to thinking about ways to help the organization to provide opportunities to spark camaraderie and personal interactions and nurture a sense of well-being, especially in a virtual setting.

Let’s Continue Investing in Our Students and One Another

These lists are by no means comprehensive — many sources of ideas are available³⁻⁸ — but hopefully what I’ve shared here provides some ideas for boosting morale. Before planning any event, be sure to consider the [Centers for Disease Control and Prevention’s core principles of safety](#), which cover:

- Current infection rate in the community
- Location of your gathering (indoor vs. outdoor)
- Number of people at the event and whether social distancing is possible
- Duration of the event
- Social behaviors of attendees before and during the event

I want to note that mental health is an even more important issue than morale, and morale boosters do not replace the very real need for mental health resources. Morale boosters are only the tip of the pandemic iceberg on which we are standing. But they can go a long way in helping students not to feel alone, and can enhance our experience as educators when we foster community. This pandemic is dragging on, but it will end at some point. In the meantime, we will continue to be creative in our

approaches, as I have already seen from so many faculty and administrators. This winter, creativity in addressing morale will pay off in tangible and intangible ways. Let's continue to go the extra mile to invest in one another and our students, and we will get through this together.

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The Eyes as a Window to the Brain: a Teaching Case

Report of Misdiagnosed Glioblastoma

Vassilios Boulougouris, OD, and Mayra Rullán, OD, FAAO | Optometric Education: Volume 46 Number 1 (Fall 2020)

Background

Glioblastoma [also known as glioblastoma multiforme (GBM)] is a type of glioma or astrocytoma, cancer that forms from star-shaped cells in the brain called astrocytes. Gliomas account for 40-50% of all primary and metastatic intracranial tumors with glioblastoma being the most common type.^{1,2}

The World Health Organization (WHO) classification grades astrocytic tumors from grade-I to grade-IV, and GBM is often referred to as a grade-IV astrocytoma. These are the most invasive type of glial tumors, rapidly growing and commonly spreading into nearby brain tissue.

In adults, GBM can be found in many parts of the brain but occurs most often in the cerebral hemispheres, especially in the frontal and temporal lobes of the brain, with 3% of lesions arising occipitally. GBM is a devastating brain cancer that typically results in death in the first 15 months after diagnosis.³⁻⁶

Glioblastoma can present with variable symptoms depending on the anatomical location of the mass. These may include persistent headaches, vomiting, loss of appetite, changes in mood and personality, changes in the ability to think and learn, new onset of seizures and speech difficulty of gradual onset. Neurological symptoms can be subtle or partially to entirely absent.

Ocular manifestations of gliomas and GBM are variable and similar to those of other space-occupying lesions and may include visual field loss. Recognizing pertinent neuro-ophthalmic signs and symptoms and appropriate ocular testing including perimetry are crucial for an immediate neurological evaluation and early detection of possible tumor growth.^{2,7-9}

The following case report describes the visual symptoms and visual field testing results associated with an occipital lesion related to glioblastoma, previously misdiagnosed as glaucoma. For optometry third- and fourth-year students and residents, the case report can reinforce clinical competence in neuro-ophthalmic care. It focuses on the proper approach to early diagnosis and management of patients with intracranial masses.

Student Discussion Guide

Case presentation

A 43-year-old Hispanic male was referred by his primary care physician concerning visual loss. The patient reported a previous diagnosis of glaucoma by an ophthalmologist in another country where he had recently traveled. The purpose of his visit was primarily to receive a second opinion about the diagnosis. He reported that while traveling in that country, he experienced an episode of headache more to the right side of his head without other symptoms, except for a disturbance in his peripheral vision. He decided to visit an emergency clinic, where he was prescribed analgesics for pain and was discharged with a diagnosis of borderline hypertension and a referral to ophthalmology. The ophthalmologist diagnosed glaucoma and recommended medical treatment with a scheduled follow-up visit. The patient's only complaint at the time of the first visit was blurry peripheral vision with no headaches or other symptoms.

Medical history revealed borderline hypertension controlled by diet and exercise. The patient was not taking any medications. Family medical history was positive for hypertension. Ocular history included myopia and astigmatism, for which the patient used glasses since he was 11 years old. His family ocular history was insignificant. He had no allergies to medications. Social history revealed sporadic, approximately once a month, alcohol consumption and no history of smoking.

Best-corrected visual acuity measured 20/20 OD and 20/20 OS. Pupils were equal in size and reacted normally to light and accommodation. Color vision measured with Hardy-Rand-Rittler plates was normal for both eyes. Extraocular muscle movements were full in each eye. The cover test confirmed absence of strabismus or any abnormal heterophoria. Confrontation visual field testing showed field loss on the patient's right side in both eyes. Anterior segment evaluation was unremarkable. Intraocular pressure measured 20 mmHg OD and 19 mmHg OS. Posterior segment evaluation showed a normal-size disc OD and OS with cup to disc ratio of 0.4/0.4 OD and OS. The optic nerves showed no elevation and had a positive spontaneous venous pulsation without glaucomatous appearance. The macula in both eyes appeared normal with positive foveal reflex, and

the rest of the posterior pole and peripheral retina were unremarkable.

Humphrey visual field (HVF) testing performed the same day showed right homonymous hemianopsia with evident macular sparing (**Figures 1 and 2**).

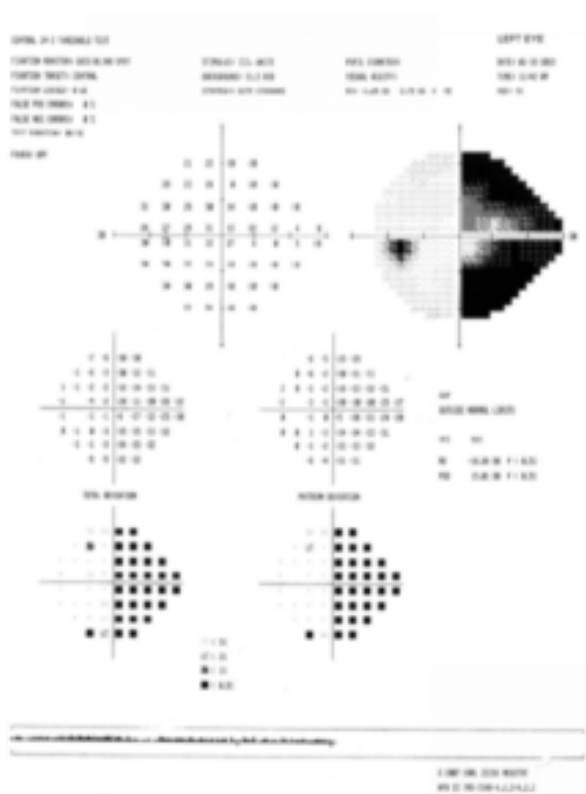


Figure 1. Automated Humphrey visual field test of the left eye showing hemianopic field loss with macular sparing.
[Click to enlarge](#)

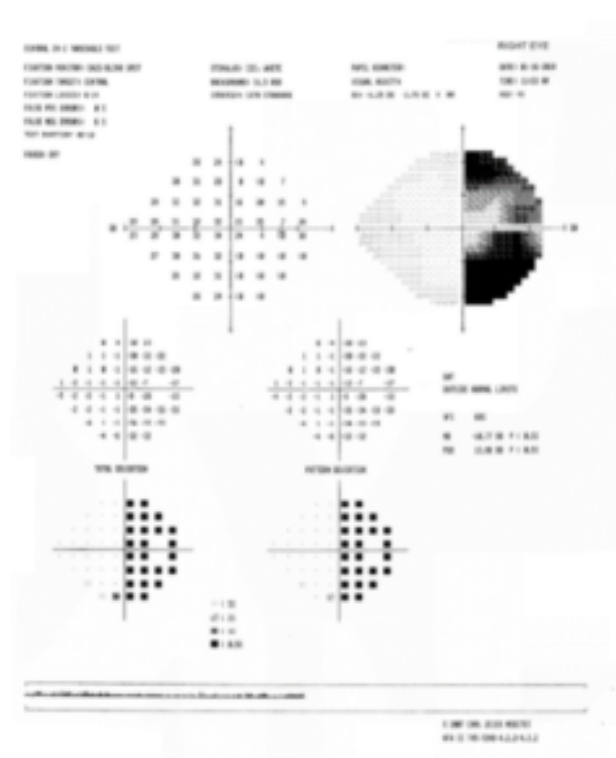


Figure 2. Automated Humphrey visual field of the right eye showing hemianopic field loss with macular sparing.
[Click to enlarge](#)

Blood pressure measured 130/90. Neurological evaluation revealed full orientation to time and place. The patient showed no motor or sensory dysfunction. Evaluation of cranial nerves 1 to 12 was normal. Coordination and balance proved to be normal.

The patient was referred to his primary care provider for hypertension evaluation. Computerized tomography (CT) without contrast was immediately ordered. The CT scan showed an intra-axial oval-shaped mass with partial fluid component at the left occipital lobe measuring approximately 5 cm long, 7.7 cm anterior-posterior and 2.7 cm transversely with minimal surrounding edema and some mass effect and midline shift to the left lateral ventricle (**Figure 3**).

The patient was immediately seen by a neurologist at a hospital facility, and magnetic resonance imaging (MRI) with and without contrast was ordered. The MRI showed a cystic mass with the same measurements as seen on the previous CT scan consistent with cystic glioma (**Figures 4 and 5**).

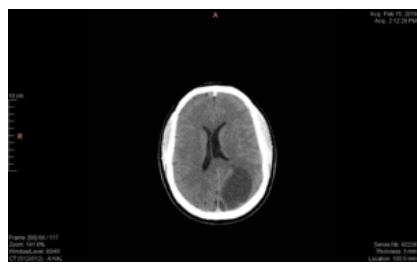


Figure 3. Axial CT scan showing hypodense large cystic lesion in occipital lobe region.
[Click to enlarge](#)

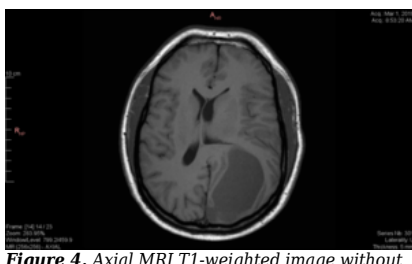


Figure 4. Axial MRI T1-weighted image without contrast showing large hypodense heterogeneous lesion consistent with a cystic glioma.
[Click to enlarge](#)

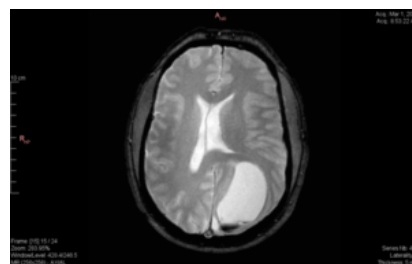


Figure 5. Axial MRI T2-weighted image showing heterogeneous lesion having high signal with surrounding edema consistent with a cystic glioma.
[Click to enlarge](#)

After being evaluated by a neurosurgeon, the patient underwent tumor resection surgery. The operation revealed an occipitoparietal tumor. The pathology of the tumor showed glioblastoma of the NOS (not otherwise specified) type (WHO grade-IV). Following brain surgery, the patient received radiation therapy and oral chemotherapy with temozolomide.

While the patient continued the oral chemotherapy, he also received the new treatment modality of tumor treating fields (TTF). Six months after the surgical resection, the patient was stable and had returned to his daily activities.

Educator's Guide

Key concepts

1. Critical thinking in diagnosis and clinical approach in primary eye care
2. The pathophysiology of the brain, its space-occupying lesions and the impact on the eyes
3. The importance of early detection of brain lesions such as GBM, which can contribute to timely treatment decisions and improve the patient's survival period
4. The importance of ensuring that patients understand their current situation and the seriousness of the matter at hand
5. The significance of ocular signs and visual field testing results in developing the diagnosis of brain tumor
6. With prompt and appropriate detection, treatment and referral, optometric physicians can play a significant role in reducing the risk of permanent vision impairment associated with brain tumors and improve the patient survival rate

Learning objectives

1. Learn the importance of recognizing systemic neurological signs and symptoms
2. Understand the importance of visual field interpretation in the detection of neurological conditions
3. Learn to differentiate life-threatening situations based on patient presentation
4. Develop a basic understanding of the types of headaches associated with intracranial tumors as well as the differential diagnosis of pain
5. Gain knowledge on the differential diagnosis of optic nerve appearance in glaucomatous vs. neurological clinical presentations
6. Gain a basic understanding of glioblastoma including signs, symptoms, necessary testing and available treatment options
7. Gain expertise in patient education and management when urgent care is required

Discussion questions

1. Basic knowledge and concepts related to the case:

- a. Describe the cell type of glioblastoma tumor, localization of the tumor in the brain and its general pathophysiology
- b. Describe the epidemiological characteristics of glioblastoma
- c. Describe the method of grading and genetic identity clues for glioblastoma
- d. Describe systemic and ocular symptoms related to glioblastoma
- e. Emphasize the importance of visual field testing in the diagnosis and monitoring of brain tumors such as glioblastoma

2. Differential diagnosis, treatment, prognosis:

- a. What are the likely diagnoses and differentials based on a patient's presenting signs, symptoms and chief complaint?
- b. List types of neuroimaging diagnostic techniques used
- c. List available treatment options for glioblastoma and emphasize the importance of inherent resistance to conventional therapy
- d. Describe the poor prognosis in glioblastoma cases

3. Critical-thinking concepts:

- a. Primary care optometrist's role in the detection and management of patients with intracranial masses, emphasizing the importance of baseline visual field testing in patients with a particular type of neurological symptoms
- b. The importance of the optometrist's role in the appropriate communication with a patient while delivering news of a lethal tumor and ensuring that the patient understands his or her current eye health condition

There are more than 120 types of brain and central nervous system (CNS) tumors. Today, most medical institutions use the WHO classification system to identify brain tumors. The WHO classifies brain tumors by cell origin and how the cells behave, from the least aggressive (benign) to the most aggressive (malignant). Some tumor types are assigned a grade, ranging from grade-I (least malignant) to grade-IV (most malignant), which signifies the rate of growth. There are variations in grading systems, depending on the tumor type. The classification and grade of an individual tumor help predict its likely behavior. Glioblastomas are glial tumors but specifically belong to the diffuse astrocytic and oligodendroglial tumor categories^{3,4} (**Table 1**).

Discussion

Teaching methodology

The case can be taught as a direct PowerPoint ground rounds seminar presented by the attending resident to third- and fourth-year students. At the end of the presentation the participants work together in small groups or individually and read the information explained in the case discussion. Their learning experience is based upon reading each discussion question and trying to respond in writing. Learning objectives can be assessed during a summative evaluation of participant correct responses against a set of predetermined answers provided in the discussion. This teaching/learning experience will:

- Allow the application of theoretical concepts to be demonstrated, thus bridging the gap between theory and practice
- Encourage active learning
- Provide an opportunity for the development of key skills such as communication, group working and problem solving
- Increase the students' enjoyment of the topic and hence their desire to learn

What are the definition and general pathophysiologic concepts of glioblastoma?

GBM are malignant grade-IV tumors in which a large portion of tumor cells are reproducing and dividing at any given time. They are nourished by an ample and abnormal tumor vessel blood supply. The tumors are predominantly made up of abnormal astrocytic cells, but also contain a mix of different cell types (including blood vessels) and areas of dead cells (necrosis).^{2,7} Glioblastomas are infiltrative and invade nearby regions of the brain. They can also sometimes spread to the opposite side of the brain through connection fibers (corpus callosum). It is exceedingly rare for glioblastomas to spread outside of the brain.

Primary glioblastomas may arise de novo, meaning they begin as grade-IV tumors with no evidence of a lower-grade precursor. De novo tumors are the most common form of glioblastoma (90%) and tend to be more aggressive and tend to affect older patients. Alternatively, secondary glioblastomas may progress from lower-grade astrocytic tumors (grade-II and grade-III) and evolve into grade-IV tumors over time. In general, these tumors tend to be slower growing initially, but can become aggressively progressive. They tend to occur in younger patients and they have a predilection for the frontal lobes.

Glioblastomas are usually diagnosed as either isocitrate dehydrogenase (IDH)-wild type or IDH-mutant. IDH-wild type glioblastomas are more common, tend to be more aggressive, and have worse prognosis than IDH-mutant glioblastomas. IDH-wild type are generally primary tumors while IDH-mutant are secondary.^{3,4,10,11}

What are the prevalence and incidence of glioblastoma?

The National Cancer Institute estimates that 22,850 adults (12,630 men and 10,220 women) were diagnosed with brain and other nervous system cancers in 2015. It also estimates that 15,320 of these diagnoses resulted in death.

Glioblastoma has an incidence of 2-3 per 100,000 adults per year and accounts for 52% of all primary brain tumors. Overall, GBM accounts for 17% of all tumors of the brain (primary and metastatic). Caucasians are affected more frequently than other ethnicities. These tumors tend to occur in adults age 45-70. Between 2005 and 2009, the median age for death from cancer of

TABLE 1

Diffuse Astrocytic and Oligodendroglial Tumors	Astrocytic Tumors	Ependymal and Other Glial Tumors
Diffuse Astrocytoma Grade II	Pilocytic Astrocytoma Grade I	Subependymoma Grade I
Anaplastic Astrocytoma Grade III	Subependymal Giant Cell Astrocytoma Grade I	Ependymoma Grade II
Glioblastoma Grade IV	Pleomorphic Xanthoastrocytoma Grade II	Anaplastic Ependymoma Grade III
Diffuse Midline Glioma Grade IV	Anaplastic Pleomorphic Xanthoastrocytoma Grade III	Angiocentric Glioma Grade I
Oligodendroglioma Grade II		Chordoid Glioma of Third Ventricle Grade II
Anaplastic Oligodendroglioma Grade III		

Table 1. [Click to enlarge](#)

the brain and other areas of the central nervous system was 64.^{1,7}

What are the grading and genetic identity of glioblastoma?

After detection of a brain tumor on CT or MRI scan, the tumor tissue is biopsied. The analysis of the tissue under the microscope is used to assign the tumor a named grade and to provide answers to the following questions:

- From what type of brain cell did the tumor arise? (The name of the tumor is derived from this)
- Are there any signs of rapid growth in the tumor cells?
- Are there any specific genetic mutations within the tumor that can help with prognosis and/or provide a target for therapy?

The tumor name and grade help determine treatment options and provide important information about prognosis.^{4,5,12}

Glioblastomas are diagnosed and classified as IDH mutations. Among these mutations, three types have been determined: IDH-wild type, IDH-mutant and, rarely, glioblastoma NOS when IDH status cannot be determined.

IDH-wild type glioblastomas include chromosomal genetic abnormalities related to chromosomes 7, 9, 10 and 13. Mutations of genes can occur in IDH-wild type glioblastomas and most commonly include:

- Phosphatase and tensin homolog (PTEN) gene, a tumor suppressor
- Epidermal growth factor receptor (EGFR) gene, which affects the cell membranes and stimulates cell division
- Telomerase reverse transcriptase (TERT) gene, which when mutated allows cancer cells continue to multiply and divide

IDH-mutant glioblastomas have mutated IDH1 and IDH2 genes. These mutations alter the cell energy requirements and cell function. Also, alteration or damage of chromosome 19 is related to this type of tumor. Finally, the gene p53, a tumor suppressor, can become mutated and lead to tumor growth.^{7,10,11}

What are the systemic and ocular symptoms related to glioblastoma?

Neurological symptoms vary depending on the anatomical location of the tumor. Symptoms of glioblastoma may appear slowly and be subtle at first. Patients may present with headaches, confusion, memory loss, motor weakness and seizures. Other patient complaints include nausea, personality changes, difficulty concentrating, hemiparesis and aphasia.

It is important to recognize headaches related to brain tumors. The nature of a brain tumor headache is different from the nature of a tension or migraine headache in various ways such as:^{2,7}

- Waking up frequently with a headache
- Headaches that wake a person up at night
- Headache pain that changes as the person changes positions
- Headache pain that does not respond to standard pain relievers
- Headaches that last days or weeks at a time and then disappear
- Headaches accompanied by various symptoms such as unexplained weight loss, increased pressure in the back of the head, dizziness or loss of balance, seizures, hearing loss, sudden inability to speak, weakness or numbness of one side of the body and uncharacteristic moodiness and anger

Ocular manifestations of gliomas and GBM are similar to those of common space-occupying lesions and may include any of the following:^{2,7}

- Blurred vision
- Visual field loss (defects correlate with site of tumor: homonymous hemianopsias)
- Spatial neglect
- Cranial nerve palsies
- Optic disc edema and atrophy
- Pupillary abnormalities, including relative afferent pupil defect
- Gaze-induced nystagmus

Most commonly, glioblastomas originate in the frontal and temporal lobes, with 3% of lesions arising occipitally.

Symptomatology varies based on tumor location. Lesions affecting the occipital lobe can present with a wide array of visual symptoms, including peripheral vision loss, visual hallucinations and several forms of visual agnosia. Masses that affect the temporal lobe often manifest with memory impairment, auditory hallucinations, spatial disorientation and peripheral vision loss. Parietal lobe tumors may cause impaired speech, lack of recognition, spatial disorders and decreased eye-hand

coordination.^{2,7}

What is the importance of visual field testing in the detection and monitoring of glioblastoma?

In many cases, neurological symptoms are absent, with visual field loss being the only manifestation. Functional studies provide a clinical context for imaging findings, increasing the predictive value of a positive imaging result. For example, HVF testing is a functional study that adds sensitivity to detecting disease evidence and progression of tumors involving the optic pathway. This fundamental concept is well-known but often overlooked in the era of increasingly sophisticated imaging techniques. Over-reliance on imaging that does not fit with clinical findings may lead to delayed treatment, inappropriate treatment or unnecessary tests.^{8,13} While imaging has played, and will continue to play, a vital role in detection and monitoring of glioblastomas, the use of accurate tools to assess clinical status should be similarly emphasized. HVF testing may prove to be useful for early detection and monitoring clinical signs of progression, as up to 50% of patients with lesions in the optic pathway show visual field defects. While HVF testing can be prone to error, well-documented reliable studies show a clear pattern of visual changes can alert clinicians to the need for prompt work-up. In the absence of highly accurate and early neuroimaging identification of tumor presence and progression, HVF testing is useful as an adjunctive clinical evaluation.^{8,9} In the case presented here, HVF showed clear, right homonymous field defects in the setting of minor visual complaints before the MRI positive findings. Therefore, for rapidly growing tumors occurring near optic pathways, such as glioblastoma, we recommend prompt neuro-ophthalmological evaluation with HVF testing. Evidence of progressive visual field deficits requires mandatory clinical monitoring and should prompt further systemic assessment and consideration of changes in treatment regimens.

What are the differential diagnoses and how may neuroimaging aid in diagnosis?

Common differentials for intracranial masses include astrocytoma, chordoma, CNS lymphoma, glioma and medulloblastoma. Also, posterior cerebral artery infarcts and hemorrhages in the infero-medial aspect of the occipital area should be included in the differential diagnosis. A biopsy is needed to determine a definite diagnosis. Key findings for all differentials are visual field defects, visual and auditory hallucinations, memory loss, visual agnosia and headaches.

Modern imaging techniques can accurately pinpoint the location of brain tumors. Diagnostic tools include CT and MRI. The latter is more sensitive and is the modality of choice.^{5,12} CT scanning can be reliable in the diagnosis of the tumor; however, it may miss small tumors. Also, lesions such as brain abscess, infarct with hemorrhage and large demyelinating lesions may look similar on CT and mimic glioblastoma. Nonenhanced CT scan findings may show a heterogeneous and not well-margined mass with internal areas of low or high attenuation indicating necrosis or hemorrhage, respectively. Enhanced CT scans show improvement of imaging results such as irregularity and inhomogeneity.^{5,12} MRI gives a higher degree of confidence in the diagnosis and is more sensitive in identifying location and size of brain tumors. In the case of glioblastoma, because the lesion is infiltrative, tumor cells are detected well beyond the area of abnormal signal intensity shown on MRIs. Techniques such as perfusion weighted imaging used in MRI demonstrate a heterogeneous mass with low signal intensity on T1-weighted images and high signal intensity on T2-weighted images. Necrotic foci, neovascularity and peritumoral vasogenic edema are significantly enhanced after the administration of gadolinium-based contrast material. Intraoperative MRI may also be useful for guiding tissue biopsies and tumor removal.¹²

Magnetic resonance spectroscopy is used to examine the tumor's chemical profile. Positron emission tomography (PET) helps detect tumor recurrence. Differentiation between residual or recurrent tumor and postoperative edema or scarring is often difficult on MRI and CT scans. PET scanning is useful in cases of active tumor, which show high metabolic activity, and in cases of scarring or edema, which usually show no increased activity at all.^{12,5}

What are the treatment options for glioblastoma?

Standard treatment is surgical resection followed by radiation therapy or combined radiation therapy and chemotherapy. If the tumor is inoperable, radiation or radiation/chemotherapy can be administered.^{10,14,5} Treatment requires effective teamwork from neurosurgeons, neuro-oncologists, radiation oncologists, physician assistants, social workers, psychologists and nurses.

Glioblastoma's capacity to wildly invade and infiltrate healthy surrounding brain tissue makes complete resection impossible.¹⁶ However, improvements in neuroimaging have helped to make better distinctions between tumor types and between tumor and healthy cells. After surgery, radiation therapy is used to kill leftover tumor cells and try to prevent recurrence.^{14,15,19} Temozolomide and bevacizumab are used in chemotherapy.¹⁸⁻²³ In 1997, the U.S. Food and Drug Administration (FDA) approved polifeprosan 20 with carmustine implant, an alkylating agent that is surgically implanted as a wafer after surgical resection and allows for drug delivery directly to the tumor site.

In addition, the medical device treatment TTF has been approved for adult patients with newly diagnosed and recurrent

glioblastoma. The device is applied with electrodes placed on a patient's scalp. It delivers alternating electric fields that exert variable but specific toxicity in proliferating cancerous cells, thus disrupting tumor growth. The TTF device must be worn by the patient for at least 18-20 hours a day during 4-6 weeks. This innovative treatment usually follows radiation therapy and surgery. FDA has approved the device for glioblastoma patients age 22 and older.^{17,20,24} Several clinical trials are being conducted to determine the efficacy of glioblastoma treatments. These trials include immunotherapy, antiangiogenic therapy, gene and viral therapy, cancer stem cell therapy and targeted therapy.^{20,25}

What is the prognosis for glioblastoma-type tumors?

The average survival time for adults with IDH-wild type glioblastoma is approximately 11-15 months. Younger age at diagnosis (less than 50 years) and complete surgical removal of the tumor can be essential factors for an improved prognosis. Biopsy results after surgery related to molecular markers can also play a role in prognosis. Patients with IDH-mutant glioblastoma have a better prognosis with average survival time of 26-30 months. Molecular biomarkers can also become important factors in the effectiveness of chemotherapy and consequently alter the prognosis. Such a marker is methylguanine-DN-methyltransferase (MGMT), which involves the methylation of the genes. MGMT becomes valuable and vital for the stability of the genes within the cells. A methylated gene becomes inactivated thus making cancer cells more sensitive to the available chemotherapy drugs. Adults with glioblastoma NOS have a similar prognosis to those with the IDH-wild type tumor, but several factors such as age, location, degree of necrosis, degree of enhancement, biomarkers and the patient's general health status prior to the diagnosis play an important role in the survival rate.^{7,11,16}

What is the optometrist's role in the detection of tumors such as glioblastomas?

The eyes are unique windows into overall health. The eye is the only place in the body through which veins, arteries and a cranial nerve can be observed without surgery. As such, the eyes can reveal information about many health conditions, including tumors.

Optometrists need to realize that their eye exam format should always include tests of peripheral vision and muscle function because these tests can often be the first line of detection of a brain tumor. Brain tumors, depending on their location, can cause loss of peripheral vision or damage the nerves that supply the muscles of the eyes resulting in abnormal eye movements, double vision or other changes in vision.

How important is patient education as part of the patient's management?

Early on, eye doctors need to solidify their relationship with patients. By building rapport based on warmth and trust, optometrists can establish a good foundation for any difficult conversation that may become necessary. Bad news comes to everyone at some point, and if optometrists deliver it using their own feelings, they can be a powerful support. It is important to understand that a doctor can never feel the way patients feel or truly understand their emotions, but can comfort them as if he or she were sharing the same emotions. The doctor must always understand the patient's perspective in a situation. As a patient asks questions such as "Will things get worse?" the doctor needs to be clear about what is meant by worse, rather than assume that the patient's concept of worse is the same.

The optometrist should never protect patients from the facts. The most serious mistakes in delivering bad news may be avoiding or not fully relaying the severity of the situation. It's natural to feel sympathy for patients and want to give them hope. Even a glimmer of hope is important. However, honesty is most important so that the appropriate care can be accomplished. It is necessary to let patients understand that the doctor will accompany them throughout this difficult process. Finally, optometrists need to know their patients, which requires listening to them and being sensitive to the fears and cultural beliefs that may cause them to refuse a particular treatment.²⁶

Conclusion

GBM is the most common and deadliest of malignant primary brain tumors in adults and among a group of tumors referred to as gliomas/astrocytomas. Classified as grade-IV (most serious) astrocytoma, GBM develops from the lineage of star-shaped glial cells, called astrocytes, which support nerve cells. Glioblastoma develops primarily in the cerebral hemispheres but can develop in other parts of the brain, brainstem or spinal cord. Because of its lethality and its variable genetic integrity, glioblastoma can respond differently to aggressive therapies, making treatment extremely difficult and challenging. Early detection can be vital and may help in prolonging the patient's survival period. GBM can present with various neurological symptoms and ocular manifestations, and recognition of such expressions can be crucial in the early detection of possible tumor growth.

As primary eyecare providers, it is important for optometrists to pay close attention to unusual visual symptoms experienced by

patients, as these symptoms can be useful in the diagnosis, localization and co-management of patients with intracranial masses. For rapidly growing tumors occurring near optic pathways, such as glioblastoma, prompt neuro-ophthalmological evaluation with visual field testing is recommended. HVF testing may very well be a first step toward bridging the gap between functional and imaging identification of tumor presence or progression involving the optic pathways.

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Recorded Lectures are Not for Everyone: Lower-Performing Students Benefit from Attending Live Lectures

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Background

Lecture styles and delivery methods are as diverse as the instructors delivering them. Most delivery methods can be placed into one of two large categories: live or recorded. The live lecture is the typical, and often preferred, in-person lecture style for most instructors.¹ Advantages of this method include personalized interactions with students, instant student feedback and the ability to monitor attendance. The recorded lecture can be given at any time, reviewed any time, and is often shorter because of a reduction in interrupting activities that occur during a live lecture.

Many institutions of higher learning have adopted recording of their live lectures and make these recordings available to students to view or review at any time. Many lecturers have concerns about the use of the recorded lecture as discussed below. One glaring question is how effective these recorded lectures are for students who stop attending live lectures.

The literature is varied on the impact of recorded lectures on student performance. A study by Shiau et al. (2018) found that in an introductory epidemiology graduate course there was no difference in overall performance between students watching traditional lectures vs. recorded lectures from home, which were followed by in-class discussions. In addition, more than half of them reported that watching recorded lectures from home was a good time management strategy.²

Some studies suggest re-watching lectures increases comprehension of presented content and results in higher exam scores.^{3,4} Williams et al. (2015) examined students' exam performances in an introductory biology course in which recorded lectures were available. The number of students that attended the live lectures was high (89.5%), and 65% watched at least one recording. A minimal difference was observed between students who attended only the live lectures and those who re-watched the lectures as recordings. The investigators concluded there was no benefit to providing the recordings because their attendance rate was high.⁵

There are other instances in which a correlation between attending live lectures and performance has been observed. Zureick et al. (2017) studied a first-year medical school histology class. Initial findings showed a positive correlation between attending live lectures and performance on exams. Upon further examination, they discovered that consistency was the key to student success. If students attended live lectures only or watched recorded lectures only, they achieved statistically significant higher scores than students who used a mixed approach in which they watched some lectures live and some recorded.⁶ Simcock et al. (2017) surveyed first-year biology students. They described a positive correlation in exam scores when participants attended live lectures and a negative correlation when they did not. Similar to Williams et al., Simcock et al. found that the majority of students attended lectures even though they would have access to the same material in a recorded format. They stated that they perceived that live lectures helped them learn and understand the material and, more importantly, it helped them keep pace with the material by providing a schedule.⁷

How do students and faculty perceive the use of recorded lectures? Groen et al. (2016), Kwiatkowski and Demirbilek (2016) and O'Callaghan et al. (2015) observed that students generally exhibited positive feelings about having access to recorded lectures.⁸⁻¹⁰ On the other hand, instructors thought that recorded lectures led to a decrease in class attendance, a restriction in their teaching style, and a reduction in one-on-one engagement. Kwiatkowski and Demirbilek also found that instructors had technical concerns, and in fact many faculty members were not familiar with the technology itself.⁹ Groen et al. reported that the faculty felt that recorded lectures helped average- to lower-performing students in achieving better grades but did not impact the success of the high-performing students. They suggested recordings helped lower-performing students because they were an additional resource and led to an increase in confidence.⁸ A survey of first-year medical students in Ireland indicated that the students preferred live lectures, and the majority stated they did not believe recorded lectures should replace live lectures.¹¹ They stated that recorded lectures should only be used as a revision tool.

Motivation behind attending lectures or watching recorded lectures varies. Some students will attend lectures from specific lecturers while watching recorded lectures of others. In addition, the subject matter and access to additional materials play a significant role in determining live attendance or watching a recorded lecture.¹² Szpunar et al. (2014) found that students can be overconfident in their learning of material when they watch recorded lectures.¹³ Watching recorded lectures also increases

on days closer to an exam.¹⁴ Jackson et al. (2018) investigated whether students were accessing recorded lectures during mandatory, scheduled self-study time. They found that students preferred to access the recorded lectures on their own time rather than during the mandatory study sessions.

This study examined student performance on exam questions regarding lecture content delivered in lectures they watched live in the classroom only, watched live in the classroom and had access to a recording of the lecture later, or watched only recorded lectures at home. This research is timely with many institutions switching to online instruction. This leads to the question of the effectiveness of these virtual learning platforms, especially for lower-performing students.

Methods

A total of 307 first-year students (152 and 155 from the first and second cohorts of the study, respectively) in a genetics/biochemistry course were evaluated and surveyed. Three lectures given by the same instructor were chosen as the lectures for which three different delivery methods were utilized. The lecture delivery methods included: in-classroom live only (L-only), in-classroom live and recorded (L+R) and recorded only (R-only). The same three lectures were used in each year of the study; however, the delivery method changed for a particular lecture across different years.

The recording of lectures was done using Panopto (Seattle, Wash.), a video recording and live streaming software. Panopto recordings can be scheduled for the time, date and classroom location of live lectures, or the software can be used to make remote recordings that are uploaded to the learning management system used by the students. Students had access to all lectures after they were delivered via Panopto recordings posted to Blackboard Learning Management System (Washington, D.C.) for their review at any time.

Attendance was recorded for each of the in-class delivery methods. Attendance was recorded as questions embedded within the lectures, which the students could only answer at the time of the live lecture. These questions were not used to determine official course performance.

To evaluate student performances, a set of predetermined questions for each lecture was included in the exams students took as part of their normal assessment for the course. The same questions were used in each year of the study. Depending on the lecture and the year the lecture was given, lectures were delivered 3-6 weeks before the assessment used to evaluate the students' performances. Statistical analysis of student performance on exam questions related to lectures given in different styles was performed using a Mann-Whitney Test using a P value of <.05 as significant.

Student perceptions of the use of live or recorded lectures were obtained by survey questions embedded at the end of the exam. Students were asked if they preferred live or recorded lectures and the reasoning behind their preference.

This study was approved by the Salus University Institutional Review Board.

Results

Assessment outcomes between lecture styles within the two cohorts

Any significant differences observed in assessment outcomes could be the result of the students' abilities in each cohort, the difficulty of the material presented, or the lecture delivery style. To assess these parameters, I compared the results within each cohort as well as the results between each cohort of the three lecture styles.

Table 1 shows the results comparing assessment outcomes (percentage of questions answered correctly on exam) from the different lecture styles within each cohort. This comparison helps to determine whether one lecture style is better than another within a cohort. There is a statistically significant difference in assessment outcomes between L+R and L-only lectures in the first cohort ($P<.05$). The first cohort also presented a significant difference when the assessment outcome for the L+R lecture was compared to that of the R-only lecture ($P<.05$). There was no difference when comparing the assessment outcomes between the L-only and R-only lecture styles of the first cohort ($P=.42$). On the other hand, the second cohort showed a statistically significant difference when comparing all lecture styles with each other (L+R vs. L-only, $P<.05$; L+R vs. R-only, $P<.05$; L-only vs. R-only, $P<.05$).

TABLE 1
Comparison of Lecture Styles Within a Cohort

	Whole Class		Top 10%		Bottom 10%	
	Cohort 1	Cohort 2	Cohort 1	Cohort 2	Cohort 1	Cohort 2
L+R vs L	80.36 vs 70.02 ($P<.05$) ^a	70.90 vs 74.32 ($P<.05$) ^a	90.67 vs 89.33 (.26)	88.33 vs 91.33 (.48)	62.00 vs 52.67 (.12)	58 vs 64.67 (.10)
L+R vs R	80.36 vs 70.02 ($P<.05$) ^a	70.90 vs 70.04 ($P<.05$) ^a	90.67 vs 91.33 (.48)	88.33 vs 92.00 (.32)	62.00 vs 49.33 ($P<.05$) ^a	58 vs 69.33 ($P<.05$) ^a
L vs R	70.92 vs 70.02 (.42)	74.32 vs 70.03 ($P<.05$) ^a	89.33 vs 91.33 (.24)	91.33 vs 92.00 (.48)	52.67 vs 49.33 (.29)	64.67 vs 69.33 (.28)

Numbers are percent averages of assessment outcomes.

^a (p-values)
L+R = live and recorded; L = live-only; R = recorded-only

Table 1. [Click to enlarge](#)

In addition to examining the whole cohort, I looked for any assessment outcomes differences between lecture styles within the top 10% and the bottom 10% of each cohort as determined by final grades (Table 1). There were no significant differences between any lecture styles in either cohort for students in the top 10% of the cohorts. The only significant difference in the lecture style assessment outcomes in the bottom 10% of the cohorts was observed between the L+R and R-only lectures.

It is important to note that the first cohort had the highest assessment outcomes average score with the L+R lecture while the second cohort had the highest assessment outcomes average score with the R-only lecture. The differences in the best lecture styles between the two cohorts could be the result of the content presented. To aid in the hypothesis, I compared the student outcomes of the same lecture style between the different cohorts. Recall that the two cohorts had these lecture styles presented as different lecture content. When the whole cohorts were examined, there were significant differences in assessment outcomes with the L+R and R-only lecture styles between the two cohorts but not with the L-only lectures. Again it is important to note which lecture style was the best or the worst for the top 10% and bottom 10% of the cohorts. The bottom 10% of the first cohort did the worst with the assessment outcomes of the R-only lecture while the same lecture style in the second cohort showed the best assessment outcomes. There were no significant differences between the top 10% of each cohort when comparing the same lecture style. Unlike the results from the whole class, comparison of the assessment outcomes between the bottom 10% of each cohort revealed a significant difference between R-only and L-only lectures (Table 2).

TABLE 2
Comparison of Same Lecture Style (different content) Between Different Cohorts

Lecture Style	Whole Class			Top 10%			Bottom 10%		
	Year 1 Lecture Style	Year 2 Lecture Style	P-value	Year 1 Lecture Style	Year 2 Lecture Style	P-value	Year 1 Lecture Style	Year 2 Lecture Style	P-value
L+R	80.20	70.90	< .05*	80.67	69.33	.38	62.00	58.33	.22
L	76.60	74.32	.87	89.33	91.33	.23	62.67	64.67	< .05*
R	76.60	79.33	< .05*	81.33	82.00	.45	69.33	69.33	< .05*

Numbers are percent averages of assessment outcomes.
L+R = live and recorded; L = live-only; R = recorded-only

Table 2. [Click to enlarge](#)

To assess whether there was true difference in assessment outcomes between two lecture styles, I compared the student assessment outcomes between the two cohorts using different lecture styles but receiving the same lecture content. The P-value for the comparison between one cohort who received a lecture as R-only to the second cohort who received the same lecture live was almost a significant value (Table 3). Table 3 indicates there were no significant differences in comparisons of lecture styles using the same lecture content in the top 10% of the cohorts. However, comparison in the bottom 10% revealed a significant difference in outcomes between R-only and L-only lecture styles of the same lecture content (Table 3).

The only significant difference in outcomes assessment when examining different lecture styles using the same content was between R-only and L-only in the bottom 10% of the cohort. I expanded the bottom percentage of the class used in the comparison to evaluate at what percentage of students there would still be a significant result. I was able to observe a significant P-value when comparing the bottom 27% but not at higher percentage values (Table 4).

TABLE 3
Comparison of Same Lecture Content Between Cohorts - Whole Class

Lecture	Whole Class			Top 10%			Bottom 10%		
	Year 1 Lecture Style	Year 2 Lecture Style	P-value	Year 1 Lecture Style	Year 2 Lecture Style	P-value	Year 1 Lecture Style	Year 2 Lecture Style	P-value
1	L+R (80.26)	R (79.33)	.31	L+R (80.67)	R (82.86)	.43	L+R (62.00)	R (69.33)	.19
2	L (79.82)	L+R (70.90)	.39	L (89.33)	L+R (88.33)	.37	L (62.67)	L+R (66.00)	.33
3	R (79.82)	L (74.32)	.05	R (81.33)	L (81.33)	.48	R (69.33)	L (66.67)	< .05*

Numbers are percent averages of assessment outcomes.
L+R = live and recorded; L = live-only; R = recorded-only

Table 3. [Click to enlarge](#)

TABLE 4
Live vs Recorded Lecture Style Using Same Lecture Content -
Comparison of Expanded Bottom Percentage

Bottom % of Class	P-value
10	< .05*
20	< .05*
25	< .05*
27	< .05*
28	.066

Table 4. [Click to enlarge](#)

Student perceptions of live vs. recorded lectures

Students were asked if they preferred live or recorded lectures via survey questions that were added to the end of their scheduled assessments. A response rate of 95.8% was achieved. Table 5 indicates that the majority of students polled stated they preferred a live lecture over a recorded lecture. Despite a true option not being given in the survey, several students reported they preferred both. The numbers in Table 5 associated with students who indicated they preferred both methods are from students who chose both methods as a choice. However, it should be noted that several other students revealed in the free response portion of the survey they prefer both methods despite only choosing one in the survey.

TABLE 5
Number of Students Who Prefer Live or Recorded Lectures

	Cohort 1	Cohort 2	Total
Live	85	72	157
Recorded	51	67	118
Indicated Both	3 ^a	16 ^a	19 ^a
Total	139	155	294

^aNote: Several students indicated they used both in their free responses; however, they chose one method in the survey.

Table 5. [Click to enlarge](#)

TABLE 6
Top and Bottom 10% Live or Recorded Preference by Cohort

	Cohort 1		Cohort 2		Preference Totals		
	Top 10%	Bottom 10%	Top 10%	Bottom 10%	Top 10%	Bottom 10%	All groups
Live	13	6	8	7	21	13	34
Recorded	1	8	5	5	6	13	19
Indicated Both	0	0	2	3	2	3	5
Totals	14	14	15	15	29	29	58

Table 6. [Click to enlarge](#)

A comparison of the preferences of the top 10% and bottom 10% of each cohort revealed differences in L-only vs. R-only lectures between the two cohorts. All but one student in the top 10% of cohort 1 preferred L-only (92.8%) while 53.3% of the top 10% of cohort 2 favored L-only with 33.3% choosing R-only and 13.3% indicating L+R. Slightly less than half (42.9%) of the bottom 10% of cohort 1 indicated they preferred L-only, which was similar to the percentage (46.7%) indicated by the bottom 10% of cohort 2. The bottom 10% of cohort 1 chose R-only (57.1%) and only 33.3% of the bottom 10% of cohort 2 favored R-only. Twenty percent of the bottom 10% of cohort 2 indicated they liked L+R. When I combined the totals of both cohorts, more than three times the number of students in the top 10% of their cohorts noted they preferred L-only, while the bottom 10% of the cohorts showed an equal preference for L-only or R-only (**Table 6**).

Students were asked in a free response form to reveal why they preferred live or recorded lectures. Several students chose more than one reason or, as mentioned previously, stated they preferred both methods. Reasons for preferring L-only were similar in the two cohorts. The top four reasons were 1) students appreciated interactions with the instructor, 2) it was easier to focus and pay attention, 3) the information presented was easier to retain, and 4) students would procrastinate if given the option of a recorded lecture (**Table 7**). Students indicated the top four reasons they preferred R-only were the abilities to 1) pause, rewind or change the pace of the recording, 2) add details of missed concepts to their notes, 3) review or repeat concepts they missed, and 4) watch the lecture on their own time and at their own pace (Table 7).

Discussion

As stated previously, many institutions of higher learning have adopted the recording of lectures to supplement their live lectures. Some institutions are even discussing a move to recorded lectures only. For example, the University of Vermont Robert Larner College of Medicine set a goal for eliminating live lectures by the end of 2019.¹⁵ It will be interesting to observe whether the University of Vermont's new model will be successful. Until then, it is important to examine the current live/recorded lecture structure and attempt to answer several questions including: how does the presence of recordings affect attendance, is attendance significant to student outcomes, what are student and faculty perceptions of the use of recorded lectures, what factors go into a student deciding to use recordings or attend a live lecture, and how do students and faculty perceive performance from the use of recordings?

Does student attendance to live lectures affect outcomes?

In my study, three different lecture styles were delivered to students enrolled in a first-year didactic basic science course while attending optometry school: live lectures that were recorded for later viewing, live lectures that were not recorded, and recorded-only lectures. Students were encouraged to attend the live lectures, and absences were held to a minimum resulting

TABLE 7
Reasons for Preferring a Live or Recorded Lecture

	Cohort 1	Cohort 2	Total
Reason for Preferring a Live Lecture			
Interactions with instructor	33	25	58
Easier to focus or pay attention	27	28	55
Information is retained	15	17	32
Would procrastinate listening to recorded lectures	10	19	29
First time exposed to material	9	19	28
More distractions with recorded lectures	10	15	25
Forces a schedule	10	9	19
Technology fails	2	2	4
Reason for Preferring a Recorded Lecture			
Having the ability to pause, rewind, change pace	34	38	72
Can add details of missed concepts to notes	19	50	69
Can review or repeat concepts	19	37	56
Can watch lecture on own time and pace	15	23	38
Pace of live lecture too fast	4	15	19
Get stuck on concepts in live lecture and fall behind	4	9	13
Will have to re-watch lecture anyway	4	1	5
Can use time used to travel to school for other things	1	1	2
Other students in the live lecture are distracting	0	2	2

Table 7. [Click to enlarge](#)

in no significant change in the data analysis (96.74% attendance rate). The R-only lectures served as an artificial absence, which could be “made up” by viewing the electronic version of the lecture.

My data suggested that the same lecture content given in different lecture styles showed no significant difference in student outcomes when examining the cohorts as a whole. These results were similar to what others have observed.^{2,16-26} This lack of a significant difference in outcomes was especially true when results from the top-performing students in the cohorts were observed.

McNulty et al. (2011) found an inverse relationship in that students who used recorded lectures more were also the poor-performing students in their basic science medical course.²⁷ This raises the question: Is the poor performance the result of the increased use of recorded lectures or is the increased use of recorded lectures required for weaker students to be somewhat successful? My data suggested that the poor performance was not the result of an increase in recorded lecture viewership as suggested by the different results of the same lecture style between the two cohorts of bottom-performing students. The bottom 10% of cohort 1 only scored on average 49.3% on questions related to its recorded lecture while cohort 2 scored on average 69.3%. Again, this would suggest that it was not the requirement of recorded viewership but rather the content of the two recorded lectures that resulted in significantly different scores.

A better comparison was one of the same lecture material but delivered in different styles. I found no significant difference in scores between any comparison of lecture styles involving the same lecture material when examining the whole cohorts or the top performers in those cohorts. However, I observed a difference when looking at the scores of the bottom-performing students. There was a statistically significant difference between a recorded lecture and a live lecture of the same material (Lecture 3). Poorer-performing students did much better with questions about the material when it was presented live. This was in better agreement with the findings of McNulty et al.²⁷ I also expanded the definition of the bottom percentage of students to see when this difference was no longer significant. I still observed a significantly better performance on material presented from a live lecture as compared to a recorded lecture for the bottom 27% of the class.

I observed a significant difference in student performances between L-only and R-only in the bottom-performing students. I might have expected to see a difference in student performances when a lecture that was live and recorded was compared to a recorded-only lecture. However, this was not the case. I hypothesize that this is the result of the difficulty of the material presented in the two lectures. In other words, it appeared that the bottom-performing students benefited from watching live lectures but not necessarily for all lectures presented. Assessment outcomes for a specific lecture style became content dependent. Another explanation comes from the results of Zureick et al., who found that students who consistently viewed L-only or R-only lectures performed better than students who viewed the lectures with both methods.⁶

One possible limitation to this section of the study was the assumption that students who attended live lectures were engaged in the lectures. Just because a student was present in the room does not mean he or she participated in the lecture. While lecturing, I have observed students whose focus is elsewhere. A lack of participation might have negatively affected their assessment outcomes.

What instructional style do students prefer?

The survey of students in the first-year basic science optometry course indicated that 53.4% preferred L-only, 40.1% preferred R-only and, despite it not being an answer option, 6.5% indicated they preferred both. It is also important to point out that in the free response portion of the survey, many other students indicated they used both despite choosing only one choice as instructed. These numbers did not differ greatly from those reported by Cardall et al. (2008), who surveyed first- and second-year students at Harvard Medical School and found that 57.2% of students watched live lectures, 29.4% watched recorded lectures, and 3.8% watched both.²⁸

Perhaps the more important data collected in this study on instruction style preferences by students was obtained from the top 10% and bottom 10% of the students. It is interesting that 72% of the top 10% of the cohorts indicated they preferred L-only despite the data that show assessment outcomes were no different for information delivered L-only or R-only. However, while the bottom 10% of the students showed an equal preference for L-only or R-only, they showed improved performances with L-only, as indicated by their assessment outcomes. These results were similar to Owston et al. (2011), who examined student perceptions of recorded lectures and academic outcomes in a large undergraduate course. They found higher-performing students did not view recorded lectures as frequently as lower-performing students. When higher-performing students viewed a recorded lecture, they viewed only sections of the lecture they needed to review and often only viewed these sections once. The lower-performing students viewed the recorded lecture several times and in its entirety.¹⁶

The question posed to students about their lecture preference was designed so they answered either L-only or R-only. This was perhaps limiting since some students indicated they liked both methods of instruction. I hypothesize that more students would

have chosen “both” had they been given the option.

Why do students prefer live or recorded lectures?

The reasons students use recorded lectures have been investigated by several studies. The lecturer, the subject and availability of other learning resources are key determining factors as to whether a student attends a live lecture or uses a recording.¹² Some students who watch recorded lectures see these recordings as a useful tool.^{11,17,19,23,29,30} They feel the recordings are helpful in their studies and use them as a resource similar to textbooks and online resources.

There are many reasons students use recordings:

- Recordings provide flexibility to view or review content at their own pace
- Recordings allow them to use other resources at the same time they view the recordings^{31,32}
- Students clarify material after attending lectures or before an assessment^{5,31}
- Recordings are used to relearn difficult material and rewrite class notes³²
- Recordings allow repeating or reviewing concepts^{29,32}
- Recordings permit students to complete other assignments or address outside commitments⁷
- Missing class necessitates the use of recorded lectures⁵

Eisen et al. found several reasons second-year medical students attend live lectures. Their primary reason to attend live lectures (96% of students reporting) was the social expectation. However, only 26% of students disclosed that they preferred to learn outside of the classroom.³³ This was by no means the only research to show that social expectations are one of the driving forces behind students attending live lectures. The participants in the Eisen et al. study also suggested that the presence of online material was one of the motivating factors that stopped them from attending the live lectures as well as, the “inconvenience of traveling to class.”³³ In this study, no students indicated social expectations as a rationale to attend live lecture and only two found that the time used to travel to class could be used for something else.

Another reason students use recordings is because they find it more efficient. Students have indicated they obtain this “efficiency” by increasing the recorded lecture’s playback speed. The students suggested that the use of video recorded lectures increased the speed of acquiring the information presented. The top two activities they did as a result of recorded lectures giving them more perceived time in their day were to study other material and sleep/rest. More than half of the participants in a study by Cardall et al. also claimed that they learned more and were able to stay focused when using the video recorded lectures.²⁸ Several subjects in this study indicated that the ability to change the pace of the lecture was one of the benefits of recorded lectures. However, they did not state if they preferred to increase or decrease the pace of the lecture.

It is of interest to note that increasing the recording speed might not actually be beneficial. Song et al. had two cohorts of medical school volunteers watch the same video on ultrasonography artifacts, a topic that was novel to them. The first cohort watched the video at a speed of 1.5X while the second cohort watched it at a speed of 1.0X. The students were then given a written assessment. The results indicated that the cohort who watched the video at 1.5X speed had a statistically significant lower score on the assessment than the cohort who watched the video at 1.0X speed. Contrary to students’ perceptions that they learned more and were able to stay better focused with recorded lectures, the study concluded that an increase in speed did not help, but might actually hinder, their performances.³⁴

Not every student gave a free response to explain his or her lecture style preference. However, this section of the study did receive approximately equal representation of reasons from students who preferred L-only (250 responses) and those who preferred R-only (276 responses). I am confident these responses represented the cohorts as a whole because little difference in reasoning existed between the two cohorts.

Future work

Many aspects of this study could yield additional and interesting results. For example, this study involved a basic science course taken by first-year optometry students. I have found that some students erroneously consider this material unrelated to the optometric profession. It would be interesting to examine student assessment outcomes from a course, such as ocular disease, that has a more direct involvement in optometry. Because poorer-performing students showed a difference in assessment outcomes when watching L-only vs. R-only lectures, I would like to examine the impact of timing of lecture availability on assessment outcomes. Finally, many recording platforms, including Panopto, allow for live streaming of lectures as they are given. It would be interesting to examine the assessment outcomes of students who view the live lecture remotely vs. students who are in class.

Conclusion

To my knowledge, this is the first study to examine the assessment outcomes of optometry students who were exposed to lectures delivered live or recorded. I found that high-achieving students, despite preferring L-only, did equally well on questions from live and recorded lectures. In contrast, lower-performing students benefited from viewing live lectures, despite their equal preference for L-only and R-only. In the end, students should be encouraged to attend live lectures. The advantages of attending the live lectures outweigh the disadvantages.

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