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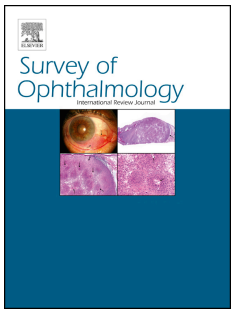

A Virtual COVID-19 Ophthalmology Rotation

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Abstract

The coronavirus (COVID-19) pandemic temporarily suspended medical student involvement in clinical rotations, resulting in the need to develop virtual clinical experiences. The cancellation of clinical ophthalmology electives and away rotations reduces opportunities for exposure to the field, to network with faculty, conduct research, and prepare for residency applications. We review the literature and discuss the impact and consequences of COVID-19 on undergraduate medical education (UME) with an emphasis on ophthalmic UME. We also discuss innovative learning modalities used from medical schools around the world during the COVID-19 pandemic such as virtual didactics, online cases, and telehealth. Finally, we describe a novel, virtual neuro-ophthalmology elective created to educate medical students on neuro-ophthalmology foundational principles, provide research and presentation opportunities, and build relationships with faculty members. These innovative approaches represent a step forward in further improving medical education in ophthalmology during COVID-19 and beyond.

Key words: Medical student education, medical curricula, undergraduate ophthalmology, virtual learning, COVID-19

I. Introduction

Currently, the undergraduate medical education (UME) community faces unprecedented challenges with the emergence of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that causes the infectious disease, COVID-19. The COVID-19 pandemic, responsible for millions of cases and hundreds of thousands of deaths nationwide[A], has required unprecedented changes in the way that UME departments deliver clinical instruction in order to comply with social distancing efforts aimed at prioritizing safety and slowing the spread of the virus.

In most medical schools, ophthalmology clinical rotations are typically considered surgical electives that students may take in their third or fourth year. Traditionally, these electives are comprised of in-person patient care experiences, teaching sessions and conferences, and scholarly projects that result in a holistic exposure to the specialty. Away rotations are electives completed at a medical school outside a student's home institution, expanding the opportunity for faculty interaction and subsequent letters of recommendation for residency applications. These away rotations are particularly important for students who do not have an ophthalmology department with a residency at their medical school, often providing the only exposure to the field. On March 17, 2020, the Association of American Medical Colleges (AAMC) recommended a temporary suspension on clinical experiences in an effort to preserve personal protective equipment (PPE) and ensure student safety.[B] This pause in rotations, while necessary, disrupted the opportunity for students to explore and experience specialty fields, such as ophthalmology. There has been a lasting effect on away rotation experiences, which at the time of submission of this article are still suspended.

Although the full impact on UME by COVID-19 remains to be seen, one outcome has been the supplementation of a traditional in-person curricula with virtual content.[7] We describe a novel design of a completely virtual elective in neuro-ophthalmology for medical students that enables clinical exposure, instruction, faculty mentorship, and research experience while still complying with social distancing measures and restrictions to away rotation experiences. To our knowledge, this COVID-19 virtual neuro-ophthalmology medical student rotation curriculum is the first of its kind to be described in the English language literature.

II. Consequences of limited clinical ophthalmology exposure for medical students

A survey of United Kingdom medical students showed 59% of students felt less prepared for their future careers as a result of suspension of clinical experiences.[7] Surgical specialties in particular have been affected by the cancellation of elective procedures with limited PPE and testing available to students[8], exacerbating an already low medical student exposure to ophthalmology.

Inclusion of ophthalmology education in clinical curriculum had already been on a steadily waning path. The proportion of medical schools requiring an ophthalmology rotation dwindled from 68% to 30% from 2000 to 2004,[23] creating potential barriers for medical students to explore and consider the specialty.

Specifically, the suspension and/or limitation of in-person clinical rotations has impaired the ability of medical students to receive clinical exposure, mentorship, letters of recommendation, and research experience required for application to residency.

A number of medical specialties, including allergy, rheumatology, surgery and dermatology, have found some success with residents currently employing technologies such as video conferencing to remotely interact with the patient in obtaining a medical history and presentation. Though resourceful, this setup critically lacks a physical exam component.[8] Additionally, the logistics of performing a complete, remote eye exam also have yet to be elucidated by ophthalmologists.[35]

The clinical rotation suspensions have impaired the ability of prospective ophthalmologists to attain a meaningful letter of recommendation. A survey of program directors, chairpersons, and members of the resident selection committee for ophthalmology residency programs indicated that 83% felt that letters of recommendation were among the most important factors considered in the resident selection process, with 70% believing that the most important letter is from an ophthalmologist.[21] Despite the pandemic, a statement released by the Association of University of Professors of Ophthalmology (AUPO) states that three letters of recommendation are required for the ophthalmology match application, with at least one letter from an ophthalmologist.[C]

These negative implications are subject to regional variability. Those enrolled in medical schools with a traditional two-year preclinical curriculum will have had 6 months less of clinical experience in comparison to their colleagues at medical schools with shortened pre-clinical schedules.[10] The impact of impact of COVID-19 on the ability of medical schools to provide faculty interaction and thus meaningful letters of recommendation has already been shown to be widely disparate between some medical schools and others.[14] If neglected as a confounding variable in residency

application review, medical students applying from an area more severely impaired by COVID-19 or without a home ophthalmology program may be disadvantaged.

While the effect on students applying for ophthalmology is obvious, the limited exposure may also impact students who do not choose ophthalmology as a career. The long-term consequences of limited medical student exposure to ophthalmology have been well studied.[31,32] Medical student graduates report lower confidence and poorer understanding of common ophthalmic disorders, which can contribute to over-referral of simple eye disorders.[32,37] Ultimately, diminished time for ophthalmic education adversely affects patient care as graduating physicians have less experience with the ophthalmic exam and diagnosing, managing, and referring patients with ophthalmic conditions.[32] Overall, limited exposure to a specialty in medical school has been shown to increase the likelihood of future medical mismanagement and misdiagnoses.[13]

An additional component of the residency application is research experience. A probability model created using the San Francisco Residency and Fellowship Matching Data found that over 99% of medical students applying for residency in ophthalmology had published clinical research.[28] Additionally, research often bolsters applicants with lower exam scores, providing another way to showcase strengths outside of the traditional curriculum.[18] Clinical research has also been impacted by COVID-19, with only essential research being permitted in most medical centers.[36] From a sampling perspective, there may be an expected decrease in follow-up and participation due to fear of contracting the virus.[36] Additionally, diagnostics used through telemedicine may not be sufficient for clinical trials.[36] Institutions and research protocols will likely need to revise their guidelines in order to accommodate clinical research during a pandemic.[36]

Therefore, there is evident strain on medical students who wish to become involved in clinical research during the COVID-19 outbreak.

III. Innovative learning modalities used to continue clinical medical education during COVID-19

While the COVID-19 pandemic has negatively impacted ophthalmic UME globally, it has also provided an opportunity to modernize educational approaches by adopting novel digital curricula. As the pandemic continues, online and virtual teaching resources are set to play a larger role of medical student education in general.[24]

The COVID-19 outbreak has disrupted the educational experience of medical students worldwide. Typically, medical schools are comprised of 12-24 months of a basic science curriculum, followed by 18 months of clinical rotations, clinical electives, sub-internships, and scholarly projects.[24] Generally, the preclinical stage can be more easily transitioned into an online format. The basic science didactic lectures have been administered using online video formats in place of lecture halls, and examinations have also been conducted using an online format. Clinical skills sessions may also occur in online virtual instructional formats, along with the implementation of dissection videos and online simulations in place of traditional anatomy laboratory dissections.[24,26]

Restructuring the clinical aspect of medical school presents more challenges in the age of COVID-19. A medical student functions as part of the clinical team as a learner, and authentic patient experiences are essential for their education. Medical schools across the world have quickly developed innovative strategies to create experiences for students who were suspended from their clinical rotations.

Didactic meetings such as academic lectures, departmental grand rounds, and seminars have been converted to online video conferences using platforms such as Cisco WebEx and Zoom.[3,12,17,25,36] The virtual format of these meetings may be more convenient in some situations and can allow for increased availability of national and international speakers at a lower cost; however, the virtual format results in less opportunity for medical students and trainees to interact and network with faculty members.[36] Social media formats such as Twitter and Facebook may also be used to disseminate medical educational material and may help foster community between medical students, trainees, and specialized physicians.[8]

Murdock and colleagues describe a multi-institutional virtual morning report format that they developed to continue education for trainees via Zoom.[20] The morning report consisted of a clinical-educational facilitator and two groups of residents and medical students as either audiovisual "active participants" or non-audiovisual "passive" participants. The passive participants were engaged in the case using the Zoom chat function, and a facilitator could filter comments and create synchronous communication between active and passive participants. Overall, they found this format to be of value to both active and passive participants as all learners were able to appreciate the clinical reasoning, differential diagnoses, and problem representations of the case.[20] Similarly, Almarzooq and colleagues describe the use of Microsoft Teams to facilitate virtual didactics.[2] They utilize different channels in Microsoft Teams for different purposes, including morning report, different fellowship committees, and teaching conferences.

To simulate clinical teaching with live patients, some schools have transitioned to using online case-based learning tutorials and videos of patient encounters.[8,25] Some

schools may consider restructuring the academic calendar to defer clinical rotations to a later date in exchange for other scholarly projects.[24,25] Another option is to involve students in the telemedicine environment.

Chandra and colleagues describe an emergency medicine clerkship they developed with medical students using Zoom to conduct virtual patient encounters.[6] Medical students conducted virtual follow-up visits with COVID-19 positive patients who were discharged from the emergency department and with patients who presented to the emergency department with general medical complaints that were discharged within the last 48 hours.[6] All encounters were supervised by a faculty preceptor, allowing for rapid assessment of student performance. This format was successful in that it allowed medical students to lead a patient interaction and obtain faculty feedback in a virtual manner.

IV. Ophthalmology-specific virtual teaching resources

In ophthalmology, telemedicine can be useful for screening and basic visits, but the learning experience is limited for students because of the inherent limitations of the ophthalmic physical examination in an indirect environment.

Shih and colleagues attempted to address this issue by replacing in-person tutorials of ophthalmic clinical skills with a virtual approach using written materials and Zoom.[27] Students first self-studied with written information and recorded videos. Next, they were placed in small groups of 30 for a 60-minute tutorial with a clinical preceptor on Zoom to discuss key points and questions. Finally, an objective, structured clinical examination (OSCE) was used for assessment.[27] This was an effective learning experience for medical students overall; however, a limitation encountered was difficulty

in effectively teaching direct ophthalmoscopy online. Successful direct ophthalmoscopy requires an understanding of the angle of approaching the patient and the physical adjustments required to view the fundus. In person tutorials are a superior method for teaching this particular clinical skill.[27]

For teaching direct ophthalmoscopy, Borgersen and colleagues systematically evaluated the effectiveness of instructional YouTube videos on direct ophthalmoscopy by evaluating their content and approach to visualization.[5] Their group provided the following suggestions for videos instructing in direct ophthalmoscopy: (1) illustrate the key themes and points essential for performing direct ophthalmoscopy; (2) consider how to illustrate the key concepts so that the learner sees what he/she should expect to see; (3) put emphasis on how to examine the fundus and interpret findings; (4) consider omitting irrelevant details, highlighting essential information, and presenting words and pictures in combination.[5]

In addition to instructional videos, the direct ophthalmoscope exam can be taught using virtual reality tools. For example, the Eyesi Direct Ophthalmoscope (VRmagic, Mannheim, Germany) is a simulator tool composed of an ophthalmoscope, mannequin head with eye sensors, and a computer monitor.[D] The student can perform the funduscopic exam on virtual patients with varying case presentations, and the computer monitor will display the fundus image and provide feedback to students on their performance. Other virtual reality tools for the direct ophthalmoscope exam include the Digital Eye Examination/Retinopathy Trainer (Nasco, Wisconsin, USA)[E], OphthoSim™ Ophthalmoscopy Training & Simulation System (OtoSim, Toronto, Canada)[F], and the EYE Examination Simulator (Kyoto Kagaku Co. Ltd., Kyoto, Japan)[G]. While these tools

are useful for students to learn the direct ophthalmoscope exam technique without direct patient contact, they are expensive and would require in person sessions for students to use the equipment.

The Virtual Ophthalmology Clinic (VOC) is an innovative web-based program which can be used during COVID-19. It is designed to enhance teaching by allowing medical students to sharpen their clinical reasoning skills by formulating a diagnosis and treatment plan on virtual patients with simulated eye conditions on off-site locations. The application of VOC resulted in increased academic performance and sustained retention over traditional teaching alone.[33] Other eLearning modules which can be used are summarized in Tables 1 and 2.

Developing learning environments during pandemics such as COVID-19 that emulate in-person experiences may require the application of simulations, digital curricula with remote mentoring, and feedback. The AUPO Medical Student Educators Council recently developed a modified list of ophthalmology objectives for graduating medical students. These objectives can be used by any medical school regardless of whether they have a department of ophthalmology, as they can be incorporated into the curricula of other medical specialties such as neurology, family practice, internal medicine, and pediatrics.[11]

The International Council on Ophthalmology[16], United States Medical Licensing Exam (USMLE)[H], and the Royal College of Ophthalmologists[I] offer further curricular recommendations and guidelines which can be followed when developing new ophthalmic modules for medical student teaching.

V. Implementation of a novel, neuro-ophthalmology elective during COVID-19

A virtual curriculum will need to address the lack of clinical experiences in ophthalmology, and should include observation time, the support of mentorship, and optimization of technology to simulate real clinical hours.[3]

We created a novel virtual neuro-ophthalmology elective designed for medical students rotating at Methodist Hospital in Houston, Texas. Through implementation of this novel virtual elective, we will provide medical students quality exposure to ophthalmology despite challenges posed by COVID-19. Although we created a curriculum for a neuro-ophthalmology specific elective, we envision that the core components can be used as a template for other ophthalmology subspecialties in the future.

The elective includes a virtual curriculum that teaches the core anatomy, diseases and concepts of neuro-ophthalmology; opportunities to study unique cases through morning reports, research opportunities, and grand rounds presentations; clinical experience via patient encounters; and assessments in the form of oral and written examinations.

a. Clinical Knowledge

The virtual curriculum is the foundation of our neuro-ophthalmology elective, developed to cover most of the level 1 topics established by the North American Neuro-ophthalmology Society (NANOS) Curriculum on the Neuro-Ophthalmology Virtual Education Library (NOVEL) web site[J]. These Level 1 topics are recommended by NANOS for medical students and cover a variety of foundational topics in neuro-

ophthalmology. The core components of the virtual elective include: morning report, grand rounds, research experience, patient encounters and oral examination.

The Level 1 topics are divided across the twenty days of the elective in a progressive manner, so that concepts build upon each other. Students will learn relevant physiology and anatomy in week 1, followed by clinical signs and symptoms in week 2. In week 3 and 4, students learn a variety of diseases relevant to neuro-ophthalmology (see Appendix for a detailed schedule).

In addition to the core components of the elective, students are provided links to EyeWiki articles and You-Tube didactic videos by an expert source (AGL) corresponding to each topic.[M,X] Finally, a brief multiple-choice exam (10-15 questions) will be administered at the end of each week to assess students' mastery of the coursework and to provide feedback for course improvements.

b. Morning Report

Students are expected to attend and participate in a virtual neuro-ophthalmology morning report daily during the elective. Morning reports, like Grand Rounds, are relatively well-suited to a virtual format and can be transitioned to a video conference platform. Through involvement in a virtual morning report, students receive similar value as attending in-person rounds, such as improving their clinical and basic science knowledge, developing clinical decision making, and learning how to present cases. We have implemented a number of strategies to facilitate student participation in virtual morning reports. Students are expected to respond to questions throughout the report from the attending physician. If there are many medical students in the elective, a select number may be assigned each day as "active" participants who are designated to

answer the morning's questions. Alternatively, students may alternate in a queue to answer questions.

To further aid student engagement, at each morning report, one student is expected to send via email the night before and then give a very brief presentation on a relevant topic. This "med-student minute" is an effective way to reinforce material from the virtual curriculum while adding clinical context. Additionally, a weekly student-run morning report session is facilitated by a medical student, providing an opportunity to lead and present a case to an audience. Students can evaluate the effectiveness of each of these methods via a post-elective survey.

We anticipate that video-based morning reports and conferences could be used in the future. The virtual nature of these conferences allows for increased medical student attendance due to decreased travel constraints and the ability for students at a different institution to attend.

c. Grand Rounds

An enrolled student is required to present at least one case during the elective at the institution's Neuro-Ophthalmology Grand Rounds via video conference. The student should confer with fellows and/or the attending physician to find an appropriate case to present, cumulating in a formal slide deck presentation

The presentation should include an introduction slide with a "focused stem" summary, relevant past medical and ocular history, physical examination including images where possible, representative imaging studies and pathology (if relevant), diagnostic procedures, and a "take-home message" summary slide.

d. Research Experience

The elective also facilitates student exploration of neuro-ophthalmology research. Students are expected to compose an article to be published on the American Academy of Ophthalmology's EyeWiki website, write a case report based on a unique patient encounter during the elective, and/or contribute to a neuro-ophthalmology book chapter. The research component of the elective is well-suited to a virtual format.

e. Patient Encounters

Patient encounters are a challenging component of a course to conduct virtually, and where possible, in-person encounters are preferred. In this elective some students may still participate in in-person patient encounters, in which they accompany and assist an attending physician during a history and physical exam. The patient examination room is situated in a manner that follows social distancing guidelines by using floor "X" stickers to mark appropriate safe distances from others.

When these accommodations are not possible, such as for students enrolling in the elective as an away rotation, virtual encounters will be provided via video chat on tablets mounted on rolling stands. Through this methodology, students will observe the entirety of the patient encounter and may be taught and questioned by the attending in a similar manner to in-person students. Though virtual students cannot carry out any of the physical exam, they may be asked to observe and evaluate signs which the attending physician elicits. Virtual students may also interact with the patient by asking follow-up questions after the history. Both virtual and in-person students may be asked to construct a differential diagnosis, describe a management plan, or write notes following these patient encounters.

f. Oral Examination

An oral examination will be administered virtually during the last week of the elective by the course director. The purpose of the oral examination is to assess the student's ability to communicate their acquired knowledge in neuro-ophthalmology in a well-organized, succinct manner. The oral examination will serve as an opportunity for the student to demonstrate their ability to develop a differential diagnosis and make clinical decisions about diagnostic testing and treatments for common neuro-ophthalmic conditions.

A typical oral examination will involve a case selected by the course director. The case will be presented to the student by the course director, followed by prompted questions by the course director to facilitate discussion. The student will be expected to answer questions relating to patient history, examination findings, differential diagnosis, and treatments.

The student will be graded based on their ability to demonstrate proper clinical approach and reasoning, rather than their memorization skills. Our oral examination format is modelled after the American Board of Ophthalmology's oral examination for graduating ophthalmology residents seeking board certification[K].

VI. Conclusion

The COVID-19 pandemic has presented numerous challenges for medical students aspiring to apply into ophthalmology. With uncertainty regarding the duration of the pandemic and the possibility of additional quarantine periods in the future, educational innovation is needed to ensure continued medical student immersion in the clinical environment. The virtual neuro-ophthalmology elective described herein is a

novel solution to expose students to a relevant, accessible ophthalmology curriculum while providing research and presentation opportunities, ultimately providing them an opportunity to obtain a meaningful letter of recommendation for their residency application. Although pandemic restrictions may eventually be lifted allowing students to return to the clinical environment, this virtual elective approach still provides value to learners. Virtual teaching conferences, didactics, and clinical experiences are innovative tools that are transforming medical education and will likely play a larger role in the future as educational technologies continue to develop. The virtual nature of these experiences is useful to foster community between students and faculty at different academic institutions. This elective format is easily adaptable to other ophthalmology sub-specialties and provides utility to other institutions navigating this new virtual environment. Future research will be needed to demonstrate the effectiveness of this elective.

Literature Search

A MEDLINE/PubMed database search was conducted to review the literature on the impact of COVID-19 on the clinical aspect of undergraduate medical education. We included articles from all years, but the review is based mainly on articles published from 2019 to June 2020, after the rise of COVID-19. All study designs were included due to the recency of the pandemic and paucity of the current literature. The search was conducted using various combinations of the following search terms: medical student learning, undergraduate medical education, ophthalmology medical student teaching, ophthalmology medical curricula, COVID-19, Coronavirus, SARS-CoV-2, Virtual Learning. Articles were reviewed and included if the information therein was pertinent to undergraduate medical curriculum during the COVID-19 pandemic. Articles were excluded if they focused solely on postgraduate education and continuing medical education. English language abstracts were screened for relevance and the full texts of articles that met the inclusion criteria were obtained. A further hand search of reference lists for articles were reviewed for other publications of significance. English abstracts for articles written in another language were reviewed and included if the inclusion criteria were met.

Disclosure

The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

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Tables

Table 1: Summary of eLearning modules and Computer Aided Learning (CAL) for teaching ophthalmology in medical curricular

Bandhu and Raje[4]	Implemented and evaluated an ophthalmology e-learning module to third year medical students and showed that it was well accepted medium of instruction by students. It was rated as fast, accessible, and of more use in the clinical subjects compared to other pre- and paraclinical subjects
Petrarcar et al.[22]	Conducted a randomised controlled crossover trial evaluating ophthalmology eLearning with traditional lectures and found students were more satisfied with eLearning with than traditional lectures with enhanced examination performance.
Steedman et al.[30]	Multi Media Learning Tools (MMLTs) were shown to significantly reduce learning time without sacrificing knowledge retention in undergraduate ophthalmology.
Allen et al.[1]	A novel 3D exploratory model and interactive learning module of the human eye showed improved pre-test versus post-test anatomy knowledge assessments in participants.
Hogg et al.[15]	Showed that providing pre-placement ophthalmology learning materials improved medical students achievement. Video materials were found to promote skill acquisition and written

	materials better facilitated knowledge acquisition. The pre-learning content consisted of 90 min of work focusing on a list of specified ophthalmic conditions.
Stahl et al.[29]	Introduced an e-learning module as part of the ophthalmology training for medical students. In the e-learning module, the students encountered the same cases as discussed during lectures and seminars. E-learning was well accepted and students with frequent use tended to achieve higher marks in their final ophthalmology exams.
Malik et al.[19]	Developed a video module to teach medical students cataract surgery and found students not only learned from this intervention, but found it more informative than spending time observing surgery.
Tsui et al.[34]	Social media can be used to teach ophthalmology concepts by integrating existing school course accounts or developing new accounts. An advantage of social media is the visual nature of ophthalmology, offering a unique platform for educational image sharing.
Borgerson et al.[5]	Evaluated the effectiveness of instructional YouTube videos on direct ophthalmoscopy by evaluating their content and approach to visualization.

Devitt et al.[9]	Evaluated an ophthalmology computer aided learning (CAL) program for medical students and found that students in the control group showed no improvement over the test period, whilst the students who had access to CAL significantly increased their knowledge base.
Succar et al.[33]	The application of virtual ophthalmology clinic resulted in increased academic performance and sustained retention over traditional teaching alone.
Shih et al.[27]	Replaced face to face ophthalmology tutorials with online teaching during COVID 19 pandemic.

Table 2: E learning resources which can be used for medical student ophthalmology teaching during COVID-19

MEDSKL: An innovative international collaboration providing free online ophthalmology content with teaching videos[L]	https://medskl.com/course/detail/ophthalmology
EyeWiki[M]	https://eyewiki.org/Main_Page
OphthoBook[N]	https://timroot.com/ophthobook/
20/20 SIM[O]	https://2020sim.com/
Medical College of Wisconsin Ophthalmic Case Studies[P]	https://www.mcw.edu/departments/ophthalmology-eye-institute/education/ophthalmic-case-studies
University of Iowa EyeRounds[Q]	https://eyerounds.org/
Eyeguru.org[R]	https://eyeguru.org/

University of Michigan Kellogg Eye Center[S]	http://kellogg.umich.edu/theeyeshaveit/
American Family Physicians: Eye and Vision Disorders[T]	https://www.aafp.org/afp/topicModules/viewTopicModule.htm?topicModuleId=66
American Academy of Ophthalmology resources for medical students[U]	https://www.aao.org/medical-students
Strabismus Simulator[V]	https://www.aao.org/interactive-tool/strabismus-simulator
Retinoscopy Simulator[W]	https://www.aao.org/interactive-tool/retinoscopy-simulator
Neuro-Ophthalmology with Dr. Andrew Lee: YouTube Channel[X]	https://www.youtube.com/channel/UC5HcfsELV0W9AqtvJvpQQSg/featured

Appendix

Virtual Curriculum Calendar

	Day	Topics Covered	Time (min)
Week 1		**Anatomy, Physiology, and Cranial Nerve Palsies**	
	1	• Introduction o What is Neuro-Ophthalmology? (Dr. Lee) • Review of Non-Neurological Anatomy o Basic eye anatomy ▪ Parts of the Eye (AAO) o Bony anatomy ▪ Skull Anatomy for Neuro-Ophthalmology (Dr. Lee) o Vascular anatomy ▪ Vasculature of Orbit (Eye Wiki)	20
	2	• Afferent Visual Pathways and Associated Defects o Homonymous Hemianopsia (Dr. Lee) o Visual Association Cortex (Dr. Lee)	20
	3	• Ocular Reflexes o Reflexes and the Eye (Eye Wiki)	35

		• Cranial Nerve III o Cranial Nerve III Palsy (Dr. Lee) o Acquired Oculomotor Nerve Palsy (Eye Wiki)	
	4	• Cranial Nerve IV o Cranial Nerve IV (Dr. Lee) o Cranial Nerve IV Palsy (Eye Wiki) • Cranial Nerve VI o Cranial Nerve VI Palsy (Dr. Lee) o Abducens Nerve Palsy (Eye Wiki)	35
	5	• Other Relevant Neuroanatomy o Control of gaze ▪ Horizontal and Vertical Gaze Centers (Dr. Lee) o Supranuclear control of cranial nerves ▪ Supranuclear Control of Cranial Nerves (Dr. Lee) o Retinal nerve fiber anatomy ▪ Retinal Nerve Fiber Layer (Dr. Lee)	20
Week 2		**Neuro-Ophthalmological Evaluation and Signs & Symptoms**	
	6	• Taking and Presenting a History in Neuro-Ophthalmology o Chief Complaint o HPI	30

		○ Past Medical History 1 ○ Past Medical History 2 ○ Past Medical History 3 • Differential Diagnoses in Neuro-Ophthalmology ○ Differential Diagnosis List	
	7	• Fundoscopy and Evaluation of Visual Function, Pupils, Intraocular Pressure and Ocular Motility ○ The 8-Point Eye Exam (AOO) • Diagnostic Testing/Imaging ○ Magnetic resonance imaging (MRI) ▪ MRI in neuro-oph (Dr. Lee) ▪ DWI - Diffusion Weighted Imaging (Dr. Lee) ○ Ultrasound ▪ Ultrasound in Neuro-Ophthalmology (Dr. Lee) ▪ Ultrasound in Neuro-Ophthalmology (Eye Wiki)	35
	8	• Abnormalities of Eye Motility ○ Nystagmus ▪ Nystagmus (Eye Wiki) ▪ Localizing Forms of Nystagmus (Dr. Lee) ○ INO ▪ Internuclear ophthalmoplegia (Eye Wiki)	45

	9	• Abnormalities of the Optic Nerve o Optic disc edema ▪ Papilledema (Dr. Lee) ▪ Papilledema (Eye Wiki) o Optic atrophy ▪ Optic Atrophy (Dr. Lee) ▪ Optic Atrophy (Eye Wiki)	45
	10	• Pupillary Changes o Anisocoria ▪ Anisocoria (Dr. Lee) ▪ Anisocoria (Eye Wiki) o RAPD ▪ RAPD (Dr. Lee) ▪ RAPD (Eye Wiki) o Light near dissociation ▪ Light Near Dissociation (Dr. Lee) ▪ Light-near dissociation (Eye Wiki)	60
Week 3		**Disorders of Afferent & Efferent Pathways and Congenital Disorders**	
	11	• Strabismus and Amblyopia o Strabismus Without Diplopia (Dr. Lee)	50

		○ Amblyopia (Eye Wiki) ○ Amblyopia in Ophthalmology (Dr. Lee) • Diseases of Retrochiasmal Visual Pathways ○ Optic Tract Syndrome ▪ Optic Tract Syndrome (Dr. Lee) • Horner's Syndrome ○ Horner's syndrome (Eye Wiki)	
	12	• Disorders of the Optic Nerve ○ Optic Neuritis ▪ Demyelinating Optic Neuritis (Eye Wiki) ○ Optic Perineuritis ▪ Optic Perineuritis (Eye Wiki) ▪ Optic Perineuritis (Dr. Lee)	50
	13	• Disorders of the Optic Nerve, Continued ○ Anterior Ischemic Optic Neuropathy (AION) ▪ Arteritic Anterior Ischemic Optic Neuropathy (AAION) • AAION (Eye Wiki) ▪ Non-Arteritic Anterior Ischemic Optic Neuropathy (NAION) • NAION (Eye Wiki) • Nonarteritic anterior ischemic	40

		neuropathy (Dr. Lee)	
	14	• Disorders of the Optic Nerve, Continued o Central Retinal Artery Occlusion (CRAO) ▪ Central Retinal Artery Occlusion (Eye Wiki) ▪ CRAO/NAION (Dr. Lee) ▪ CRAO: Stroke Workup (Dr. Lee) o Compression/Infiltration ▪ Optic Nerve Tumors (Dr. Lee)	35
	15	• Congenital, Developmental and Genetic disorders o Retinopathy of Prematurity ▪ Retinopathy of Prematurity (Eye Wiki) o Phakomatoses (neurocutaneous syndromes) ▪ Ocular manifestations of phakomatoses (Eye WIki) ▪ Von Hippel-Lindau Syndrome • Von Hippel-Lindau Syndrome (EyeWiki) o Leber Hereditary Optic Neuropathy ▪ Leber Hereditary Optic Neuropathy (Dr. Lee) ▪ Leber Hereditary Optic Neuropathy (Eye Wiki)	60
Week 4		**Other Disorders with Neuro-Ophthalmic Manifestations**	
	16	• Vascular Disorders	45

		▪ Brainstem strokes • Ophthalmologic manifestations of brainstem stroke syndromes (Eye Wiki) • Lateral Medullary Syndrome (Dr. Lee) ▪ Hypertension • Hypertension and Neuro-Ophthalmology (Dr. Lee) ▪ Diabetes • Diabetic Retinopathy (Eye Wiki) • Diabetes in Neuro-Ophthalmology (Dr. Lee)	
	17	• Inflammatory/Autoimmune Disorders o Giant cell arteritis ▪ Giant Cell Arteritis (Dr. Lee) ▪ Giant Cell Arteritis (Eye Wiki) o Sarcoidosis ▪ Sarcoidosis in Neuro-Ophthalmology (Dr. Lee) ▪ Neurosarcoidosis (Eye Wiki) o Antiphospholipid antibody syndrome ▪ Anti phospholipid antibody syndrome (Dr. Lee)	60
	18	• Inflammatory/Autoimmune Disorders, Continued	55

		○ Behçet disease ▪ Behcet's Disease (Eye Wiki) ○ Granulomatosis with polyangiitis ▪ Granulomatosis with Polyangitis (Eye Wiki) ○ Multiple Sclerosis ▪ Multiple Sclerosis (Eye Wiki)	
	19	• Inflammatory/Autoimmune Disorders, Continued ○ Myasthenia Gravis ▪ Myasthenia Gravis (Eye WIki) ▪ Ocular Myasthenia Gravis (Dr. Lee) • Other ○ Idiopathic Intracranial Hypertension ▪ IIH (Dr. Lee) ▪ IIH (Eye Wiki)	35
	20	• Infectious Diseases ○ Herpes Zoster ▪ Herpes Zoster Optic Neuritis (Eye Wiki) ○ Syphilis ▪ Syphilis in Neuro-Ophthalmology (Dr. Lee) ▪ Ophthalmological Manifestations of Syphillis (Eye Wiki) ○ Tuberculosis	60

		▪ Tuberculosis and the Eye (Dr. Lee) ▪ Tuberculosis Uveitis (Eye Wiki) o HIV ▪ Ocular Involvement in HIV/AIDS (Eye Wiki)	