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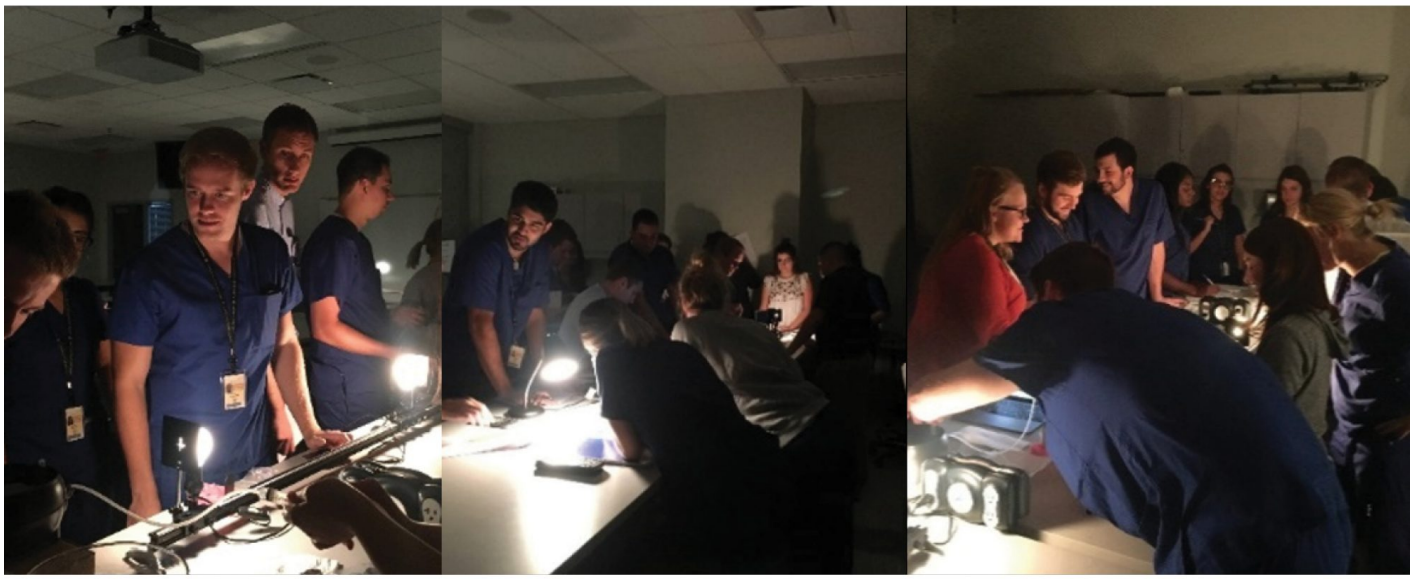

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An Inquiry-Based Approach to Teaching Sphero-Cylindrical Ametropia

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Background

A clear understanding of the optics of the eye remains a fundamental basis of optometric education.[1-7] As technology continues to improve, modern instrumentation and corrections can utilize measurements that are more sophisticated and manufacturing standards that are more precise. Optometrists need a clear understanding of the optical basis of sphero-cylindrical ametropia and the relationship between the refractive state of the eye and its correction to be able to evaluate and utilize new and evolving technologies.

Students in the first-year program at the Midwestern University Arizona College of Optometry (AZCOPT) are required to take the OPTOG 1540 Geometrical and Physical Optics I course as part of the OD-1 curriculum. The course is in the first quarter of the optometric program and includes 30 hours of lecture and 10 three-hour laboratory periods over the course of the 10-week quarter. Lecture and laboratory materials were developed over the course of five administrations with the same course director. The entire class (approximately 55 students) attends lecture together and two laboratory sections are scheduled on the same day with approximately half the class randomly assigned to each section at the beginning of the quarter. The laboratory is equipped with eight stations with optical rails, lights, optical elements and other supplies. Most labs contain traditional demonstrations and activities designed to give students hands-on experience with the lecture content. Labs are designed to take place after the introduction to material in lecture, and each laboratory has a pre-lab reading assignment. A pre-lab assignment and a post-lab assignment are graded.

At AZCOPT, students learn the fundamental concepts of spherical and sphero-cylindrical ametropia in their first quarter of study in the Geometrical and Physical Optics I course. For many years, sphero-cylindrical ametropia was taught through a series of approximately six hours of lecture and one three-hour laboratory. Sphero-cylindrical ametropia is one of the most clinically relevant topics covered in the first-year optics curriculum and one of the most challenging. Some of the related course learning goals are summarized in **Table 1**. The introduction first-year optometric students receive in this course forms the basis upon which they learn advanced concepts related to spherical and sphero-cylindrical ametropia in optometric methods, contact lens and low vision courses and ultimately translate to clinical knowledge.[8-9] Understanding cylindrical and sphero-cylindrical optics necessitates thinking about an optical system in three-dimensions, and students often comment that the relationship between the power of the eye/lenses and the orientation of images is difficult to visualize. Students also share that it is difficult to simultaneously consider the relationship between the power of the eye (keratometry), the power of a prescription (ophthalmic optics) and the various notations used to represent these components (transcription). Students often show a gap between the knowledge they should have obtained about sphero-cylindrical optical systems and what they display on examinations and in their methods courses.

TABLE 1
Learning Goals Related to Spherical and Sphero-Cylindrical Ametropia in OPTOG 1540 Geometrical and Physical Optics I

- To be able to explain the optical basis of refractive error, its measurement and its correction
- To understand thin lens models of ametropia
- To understand the changes in refractive power between the spectacle and corneal planes
- To understand changes in retinal image size with different forms of ametropia (axial vs. refractive)
- To understand thin lens spherical and sphero-cylindrical imaging with point objects and images as well as extended objects and images
- To understand the relationship between power and axis meridians
- To understand the difference between plus and minus cylinder notations and convert between the two
- To understand the difference between using a cylindrical lens to form an image and looking through a cylindrical lens (the role of the eye)
- To understand the interval of Sturm
- To understand the characterization of astigmatisms in the human eye

Table 1. *Click to enlarge*

TABLE 2
Comparison Between Inquiry-Based and Traditional Sphero-Cylindrical Ametropia Labs

Traditional Lab	Inquiry-Based Lab
Students follow step-by-step instructions to make observations	Students make observations at starter stations to gain exposure to a variety of phenomena
Students receive a hands-on experience with complex material	Students define and investigate an aspect of the material that is of interest to them
Students follow a clearly defined process to ensure exposure to all content goals	Students communicate their results with the class and become subject-matter experts

There are many possible approaches to the design and execution of learning activities in the laboratory setting. There is a long history of laboratory use in science education, which is believed to provide students with valuable experiences with science concepts and the processes required in scientific fields. An inquiry-based laboratory is one way to increase the depth of conceptual and quantitative

understanding and stimulate critical-thinking.[10-18] Here, inquiry refers to the fact that students learn process skills relevant to optometric practice, such as problem-solving, data analysis and communication, along with the content centered on the concepts of sphero-cylindrical ametropia. Traditional laboratories on the other hand can be any hands-on activity outside a lecture setting where students work to visualize information. They can provide a hands-on and active experience with the material, but in a traditional lab, learners are typically following a set, clearly defined procedure to simply observe and record findings. This could include activities with physical materials or computer simulations that often at least appear to have a "right" answer with errors attributed to malfunction or human error. The learning goals for traditional laboratories are typically content-driven rather than process-driven.[19-24] Traditional lectures and laboratories are widely accepted as effective methods to deliver basic content to students and have a long history of use in scientific education. A comparison between the two methods is presented in **Table 2**.

Inquiry-based teaching methods were used in an optometric setting by the author as a graduate student instructor in an ophthalmic aberrations laboratory. This lab was an additional lab in that course and allowed students to look at their own aberrations using a computer simulator. Then they worked in groups using a case-based approach to further investigate one condition or clinical problem. One major question remains. Are inquiry-based labs well-suited to replace traditional labs in an optometric setting, or are they better suited to be used to strengthen and widen the scope of knowledge? In addition, if used in combination with a traditional laboratory, is there an ideal order to present the labs: inquiry then traditional or traditional then inquiry?

Methods

Two innovative and interactive laboratories with an inquiry-based and a traditional component on sphero-cylindrical ametropia were implemented, replacing the one traditional lab on sphero-cylindrical lenses and the laboratory practical exam. To increase the depth of knowledge of the refracting states of the eye and their correction, inquiry-based sphero-cylindrical ametropia laboratories provide students with an opportunity to further explore and work with eye models and their own visual systems to increase the depth of their understanding of these concepts. This innovative laboratory approach can be challenging and lead to periods of questioning, but ultimately the goal is to extend the students' fundamental understanding of a set of topics (e.g., Table 1) that form the basis of understanding in many future classes and future clinical practice.[16,18,20] Inquiry-based laboratory activities can be challenging to students as they are more open-ended with students taking ownership over the scientific process. They often hit a point where they are stuck or do not know how to proceed, as is the case in the practice of vision science and optometry. As a result, more instructors and teaching assistants facilitated the inquiry-based lab periods to help the students design and execute their investigations compared to a traditional lab setting. (Most sessions had three to four for inquiry vs. two for traditional).[19-24] An inquiry-based laboratory was added to the earlier portion of the course to introduce the concept, replacing a practice lab practical, so inquiry was not a completely new process when the sphero-cylindrical ametropia labs were administered towards the end of the quarter.

The traditional sphero-cylindrical ametropia lab was taught for five years at AZCOPT for one laboratory period for a total of three hours. The lab began with a guided set of questions in response to which the students looked through or made observations about cylindrical lenses of various powers, combinations of lenses, pinholes and slits. They were asked to make a variety of observations including blur associated with points and extended objects, image movement, image formation and other simple observations. This introduction was followed by step-by-step instruction where students set up different sets of lenses on the optical rail. This included image formation with a single positive cylindrical lens and a variety of combinations of spherical and cylindrical lenses and screens to represent different types of regular astigmatism. For the eye models, students were also walked through the process of correcting these eyes with additional trial lenses.

Two inquiry-based laboratories on cylindrical and sphero-cylindrical lenses and sphero-cylindrical ametropia were implemented in addition to shortened versions of the traditional labs by increasing the time from one laboratory period to two. The new inquiry-based laboratories each included a traditional component and an inquiry component. All students received both approaches to the same content on the same day. To determine whether the order in which the two lab sections are offered matters for the learning outcomes, one section received the traditional lab first and the other received the inquiry-based lab first. These were immediately followed by the other component. The order was then switched the following week so

all students experienced both orders to limit differences between groups.

Figure 1. *Left: This station demonstrated relationships between object and image distances, cylindrical lens orientation and image orientation. Right: This station used vases of various sizes filled with water to demonstrate relationships between index of refraction and curvature. Click to enlarge*

Figure 2. *Top left: This station used a model eye setup on the optical rail to demonstrate sphero-cylindrical ametropia and correcting lenses (glasses vs. contact lenses). Top middle, top right, top bottom: This station used eye models from Pasco to demonstrate phenomena related to sphero-cylindrical ametropia. A variety of options allowed the creation of various ametropic eyes: the ability to fill the eyes with water; objects on the optical rail or a computer; spherical and cylindrical lenses to act as the eye or correction; apertures to act as pupils; a moveable "retina" screen.*
Click to enlarge

The inquiry-based labs were similar in format. In the first 15-20 minutes, students split into two to three groups to rotate through starter stations where they observed phenomena related to cylindrical and sphero-cylindrical lenses (week 1) and sphero-cylindrical ametropia (week 2). Each station began with a facilitator introduction to the station with demonstrations followed by time for the students to explore and discuss. The stations included:

Week 1: spherical and sphero-cylindrical lenses **(Figure 1)**:

1. Cylindrical and sphero-cylindrical lenses and image formation

2. Index of refraction and curvature

3. Looking through cylindrical and/or spherical lenses and slits/pinholes. Various +/- cylindrical and spherical lenses, pinholes and slits were provided from trial lens kits as well as near and distance eye chats and contrast charts

Week 2: sphero-cylindrical ametropia **(Figure 2)**:

1. Astigmatic eye models on optical rails and their correction

2. Pasco astigmatic eye models (https://www.pasco.com/prodCatalog/OS/OS-8477_human-eye-model/index.cfm)

3. Computer simulations of spherical and sphero-cylindrical imaging, e.g, sight simulator from prescription (http://www.billauer.co.il/simulator.html)

The students formed groups of three to four people in order to ask and refine a question and design and execute their own in-depth investigations into one aspect of cylindrical and sphero-cylindrical lenses (week one) and sphero-cylindrical ametropia (week 2). Members of each group presented their findings to the rest of the class in the final 20 minutes, as they had become the subject-matter experts. The total time for the inquiry-based lab component was approximately two hours.

A short quiz and survey were administered each week in the middle of the laboratory period after the first part of the lab was completed (either traditional or inquiry-based) to assess student knowledge and perception. Each lab was also followed by a quiz and survey in the next lecture for the same reasons. To ensure that any differences did not impact student assessment, the quiz scores were used exclusively as research data and did not count in the course grade. Students received full marks for

finishing the quizzes and surveys. An analysis of the grade average and distribution was performed, and students were informed of any aggregate differences for their information.

The quizzes and surveys included several content-based questions. Students were asked to rate the lab they just completed (inquiry-based or traditional) in the middle of the lab period, and on the following day separately rate both labs on a scale of 1-10. Students were also asked about the impact of the lab(s) on their learning experience and about the order of the labs (only in class following both labs). They were asked opinion-based questions (rated disagree to agree) regarding their ability to solve basic and complex optics questions and if the lab enhanced their ability to solve problems and their conceptual knowledge. There were additional open-ended questions. An analysis was performed to assess student performance on these quiz/surveys.

Fifty-six students were enrolled for the first time in the OPTOG 1540 Geometrical and Physical Optics I course when two new inquiry-based laboratories were implemented in addition to traditional laboratories. All students participated in laboratories, quizzes and examinations as a part of the normal class activities. An analysis was performed to assess student performance on these quiz/surveys. Midwestern University IRB approval was received for this study (AZ #1075). Prior consent for disclosure of academic records was not required for this study, consistent with the Student Handbook, Appendix 3.D.2.g. Confidentiality was maintained and no names were used in the compiled data file. There was a risk of loss of privacy or breach of confidentiality, but a de-identified records review and data retrieval minimized such risks.

Results

The 56 students enrolled for the first time in the OPTOG 1540 Geometrical and Physical Optics I course participated in both new inquiry-based laboratories. They also completed traditional laboratories on the same day in a randomized order as described in the methods section. These were part of the requirements for the OPTOG 1540 Geometrical and Physical Optics I course. All 56 students completed the two survey/quizzes administered in the lab period, 52 students completed the in-class survey/quiz after the first week, and 55 students completed the in-class survey/quiz after the second week.

Figure 3. *Midwestern University Arizona College of Optometry students at a starter station for the inquiry-based lab.* *Click to enlarge*

Figure 4. *Optical rail setup of an astigmatic optical system (left). Eye models used with water (middle) and air (right) in an investigation of the impact of astigmatism on retinal blur.* *Click to enlarge*

All students successfully participated in the starter stations and recorded vocabulary and questions. **Figure 3** illustrates students engaging with the starter materials. The entire group brainstormed questions together resulting in the investigation questions summarized in **Table 3**.

Students then proceeded with an investigation with the help of the instructor and facilitators. The inquiry labs culminated in the delivery of short presentations. Pictures from the investigations are shown in **Figure 4**.

During the first week's spherical and sphero-cylindrical lenses laboratories, 56 students completed a quiz and survey in lab immediately after either the inquiry-based lab (27) or the traditional lab (29). 52 students completed the quiz and survey in the next lecture. Results comparing performance on the four quantitative questions revealed no significant differences. Results comparing student ratings of the labs in their usefulness in gaining knowledge about cylindrical and sphero-cylindrical lenses on a scale of 1-10 in whole numbers where 1 is not useful and 10 is extremely useful also revealed no significant differences. These results are in **Table 4**. During the second week's sphero-cylindrical ametropia laboratories, 56 students completed a

quiz and survey in lab immediately after either the inquiry-based lab (29) or the traditional lab (27). Fifty-five students completed the quiz and survey in the next lecture. Results comparing performance on the four quantitative questions and the questions asking students to rate the labs are presented in **Table 5**. There was again some variability, but no significant differences.

As discussed in the methods section, the survey included some open-ended questions. The responses to these questions highlighted the value of the diverse laboratory experiences. Selected responses are in **Table 6** and **Table 7**. In addition to the comments in the tables, numerous comments indicated the students would like more time; some felt they had to rush. This limitation of this first administration is addressed in the discussion section. Numerous comments highlighted that the students felt the traditional lab should take place before the inquiry-based lab, and many students requested more guidance.

TABLE 3
Questions for Inquiry-Based Laboratory Investigations

Week 1: Cylindrical and sphero-cylindrical lenses	Week 2: Sphero-cylindrical ametropia
• What happens when you combine sphere and cylinder lenses? • Where is the CLC using a sphero-cylindrical lens? • What is the impact of cylindrical and sphero-cylindrical lenses on image quality and image formation? • What happens when you change the axis of cylinder hitting the vase and how does this change our image formation? • What is the impact of sphero-cylindrical lenses on the conoid of Sturm? • What happens when you combine spherical and +/- cylindrical lenses? • What is the image formed at the CLC with different objects? • What is the difference between blur from a point and an extended object? • What is the role of the power and axis orientation? What is the role/use of @ and x?	• What happens to CLC with change in medium? • How does pupil shape change image quality? • What happens to the image with different mediums? • What is the size of the image with more or less astigmatism? • How does the magnitude of astigmatism impact the size of the CLC? • How does a myopic and a hyperopic eye affect image size? • How does accommodation impact astigmatism? • How does correction of astigmatism relate to powers of the eye? • How do different pupil sizes affect astigmatism along different axes? • How does the medium impact the Rx? • How do different combos of power and retina relate to classification of astigmatism?

CLC = circle of least confusion

Table 3. *Click to enlarge*

TABLE 4
Student Performance on Spherical and Sphero-Cylindrical Lenses Quiz and Lab Ratings

	Inquiry 1st In Lab Average (SD)	Trad 1st In Lab Average (SD)	Inquiry 1st In Class Average (SD)	Trad 1st In Class Average (SD)	Comparisons
Performance on four quantitative questions	2.6 (1.1)	2.8 (1.1)	3.0 (1.0)	2.9 (1.0)	p=0.81 (in labs) p=0.12 (labs/class inquiry 1st) p=0.52 (labs/class trad 1st) p=0.79 (in class)
Rate the **inquiry** laboratory activity this week in its usefulness in gaining knowledge about cylindrical and sphero-cylindrical lenses on a scale of 1-10 in whole numbers where 1 is not useful and 10 is extremely useful	7.3 (1.5)		7.0 (1.7)	6.1 (2.1)	p=0.12 (in labs) p=0.47 (labs/class inquiry 1st) p=0.26 (labs/class trad 1st) p=0.83 (in class 1st lab)
Rate the **traditional** laboratory activity this week in its usefulness in gaining knowledge about cylindrical and sphero-cylindrical lenses on a scale of 1-10 in whole numbers where 1 is not useful and 10 is extremely useful		6.5 (2.2)	7.0 (1.5)	7.1 (1.6)	p=0.06 (in class other lab) p=0.86 (in class inquiry lab) p=0.09 (in class trad lab)

Table 4. *Click to enlarge*

TABLE 5
Student Performance on Sphero-Cylindrical Ametropia Quiz and Lab Ratings

	Inquiry 1st In Lab Average (SD)	Trad 1st In Lab Average (SD)	Inquiry 1st In Class Average (SD)	Trad 1st In Class Average (SD)	Comparisons
Performance on four quantitative questions	2.1 (0.9)	2.3 (0.9)	2.4 (0.8)	2.5 (0.9)	p=0.65 (in labs) p=0.10 (labs/class inquiry 1st) p=0.18 (labs/class trad 1st) p= 0.70 (in class)
Rate the **inquiry** laboratory activity this week in its usefulness in gaining knowledge about cylindrical and sphero-cylindrical lenses on a scale of 1-10 in whole numbers where 1 is not useful and 10 is extremely useful	5.5 (1.9)		6.0 (2.1)	6.7 (1.4)	p=0.19 (in labs) p=0.34 (labs/class inquiry 1st) p=0.38 (labs/class trad 1st) p=0.32 (in class 1st lab)
Rate the **traditional** laboratory activity this week in its usefulness in gaining knowledge about cylindrical and sphero-cylindrical lenses on a scale of 1-10 in whole numbers where 1 is not useful and 10 is extremely useful		6.1 (1.5)	6.3 (1.9)	6.5 (1.6)	p=0.45 (in class other lab) p=0.18 (in class inquiry lab) p=0.67 (in class trad lab)

Table 5. *Click to enlarge*

TABLE 6
Selected Responses to Survey Questions During Lab and In-Lecture
(Week 1: Spherical and Sphero-Cylindrical Lenses)

What do you think the general impact of the lab was on your learning experience? Feel free to explain below.
• "When doing traditional labs it is much easier to focus more on the right answer and less on learning/grasping the material. Inquiry based makes it much easier to grasp the material."
What aspects/techniques used in this lab helped you in grasping the concepts?
• "Struggling on our own to answer a question helps you to really remember what you learned." • "Our presentation helped increase my knowledge about understanding the difference between vertical & horizontal. i.e. where power is in relation to axis." • "Having no "right answer" so I wasn't trying to complete it as fast as possible. Instead I strove for understanding." • "The inquiry lab and the presentations helped me grasp the big concepts."
Other comments (Say what you want to say)
• "I like the inquiry labs as it does help me with my understanding, but the presentation aspect is hard as struggling to put my conceptual understanding into words is difficult." • "Overall I like the inquiry labs. I think they help me to understand and grasp the concepts better." • "Inquiry based probably will be more memorable since we created our own experiment." • "I would like to do more inquiry lab and less of the normal lab." • "I really like the inquiry based lab and I think they help to increase my understanding of the lab."
What aspects/techniques would you like to see changed? (Please explain)
• "I feel like both labs should have been prior to lecture material. I feel like by the time we got to lab, I already had a good sense of the material & actually seeing it 1st in lab would have helped visualize it for lecture."

Table 6. *Click to enlarge*

TABLE 7
Selected Responses to Survey Questions During Lab and In-Lecture
(Week 2: Sphero-Cylindrical Ametropia)

What aspects/techniques used in this lab helped you in grasping the concepts?
• "Working through the traditional lab helped solidify my understanding." • "I really liked doing the traditional lab first. This way you get up to speed on concepts and start to find questions naturally as you work through the lab using the rail. Then, by the time the inquiry lab comes, you know more and already have some questions." • "The traditional lab helped me grasp the concepts, which then allowed me to use those concepts in the inquiry part of the lab." • "The new eye models are awesome! Nice to be able to test out our hypothesis to questions we may have."
Other comments (Say what you want to say)
• "The new eye models are awesome for really being able to understand vertical vs. horizontal blur by using computer images." • "I liked doing traditional first and then inquiry. This gave you a good basis before inquiry lab." • "Inquiry based lab made things more memorable than traditional."
What aspects/techniques would you like to see changed? (Please explain)
• "I would like some more structure." • "Doing a short traditional lab before an inquiry lab really helped my group coordinate how to carry out our experiment." • "I would always do the traditional lab first because it helps to go into the inquiry section with more understanding of the concepts and the math." • "A little more direction for the inquiry lab. Maybe premake questions so that they are less general and/or find a different system of choosing/assigning questions – so groups don't get stuck w/ a question that is either too hard, too confusing, or not what they wanted to inquire about." • "I personally liked doing traditional first to help build my foundation of knowledge so I know what to be inquiring about."

Table 7. *Click to enlarge*

Discussion

Inquiry-based labs are designed such that students will learn process skills relevant to optometric practice such as problem-solving, data analysis and communication along with the content goals. The new laboratories presented here centered on a difficult topic: cylindrical and sphero-cylindrical lenses and sphero-cylindrical ametropia. The goal of participating in these interactive laboratory sessions was for students to explore and develop a deeper understanding of the individual optical concepts and how they come together. Students also had the opportunity to participate in the traditional labs, which allows assessment of whether the inquiry-based approach would be best implemented before, after, or in place of the current teaching methods.

Although there was no statistical difference in the overall final exam grades or overall course performance, a number of outside course factors should be considered in order to evaluate the impact of the inquiry-based labs. The year without the inquiry-based labs had a laboratory practical examination prior to the written final examination. This resulted in a sequence such that the traditional astigmatism laboratory was completed weeks earlier in the quarter allowing more time for review

prior to the final examination. The material was also examined prior to the final exam on the practical, hands-on examination. There were also some areas identified in need of improvement after the first implementation of the inquiry-based labs, specifically a lack of time to finish all parts of the labs that may have played a role in performance on these items. The true test will be students' future performance in upper-level courses and on the national board exam, which would make interesting follow-up studies.

It is extremely important for optometrists to be careful consumers of new technology. An increasing number of measuring and correcting devices are utilizing the knowledge of ocular aberrations in their design. It is not feasible to adopt all new equipment or work with all companies developing correcting devices. Therefore, having a deeper understanding of the vocabulary used and the patient populations for which this may provide maximum benefit is important for future success. Astigmatism is one of the most basic aberrations and ultimately one of the easiest to understand. Although many students already know how to transpose a prescription or have heard of astigmatism through personal experiences, the 3D and complex nature of the concepts related to sphero-cylindrical ametropia and its correction remain a challenge for many students. This is a topic they will see again in many classes and in practice, and an innovative approach to extending their knowledge early in their careers could be extremely meaningful and have long-reaching impact.

Preliminary results suggest some value in the addition of inquiry-based labs in an optometric setting. Some form of traditional instruction and/or laboratory demonstration may always be needed or at least enhance the experience. Many additions and revisions to these laboratories can be considered with the goal of an improved educational experience and enhanced long-term application of knowledge. One consideration is a variation on the hybrid experience whereby one week of traditional laboratory and one inquiry-based lab occur rather than a traditional and an inquiry component both occurring twice on two separate weeks. Other changes, such as submission of questions for investigation in advance through homework or a pre-laboratory activity or assignment, may simplify parts of the experience. Another consideration could be a different approach to the presentation of results such as having students deliver their presentations the following week or in class or completing some sort of laboratory report. Inquiry-based laboratories can often be more time-consuming for reasons that include the fact that students may face situations that are more challenging in which they feel stuck. Working through these elements can lead to greater ownership of the learning process and the development of useful skills for the future, but it requires more time and many of these suggestions address that. One consideration is that inquiry-based labs are extremely well-suited for strengthening and widening the scope of knowledge rather than introducing a topic.

Conclusion

New inquiry-based labs were introduced in the Geometrical and Physical Optics I course at AZCOPT. Students were put outside their comfort zone and extended their knowledge of astigmatism. The study implemented and utilized innovative teaching strategies in AZCOPT's optometry program. No statistical differences in exam or course performance were found with the use of traditional vs. inquiry laboratories. At least some form of traditional instruction seems to be required in order for students gain the maximum benefits from an inquiry-based laboratory. The results may inform program faculty regarding the implementation of other innovative teaching methods such as problem-based learning, a flipped classroom, etc. Finally, the results may provide additional evidence to guide educational practices for optimal outcomes on the national certification examination.

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References

1. Accreditation Council on Optometric Education. Accreditation manual: professional optometric degree programs, sections 2.1-2.10 [Internet]. St. Louis (MO): American Optometric Association; 2014 [cited 2019 Sep 7]. Available from: https://www.aoa.org/optometrists/for-educators/accreditation-council-on-optometric-education/accreditation-resources-and-guidance/optometric-degree-programs-
2. Harris MG, Kashani S, Saroj N. An evaluation of the new curriculum at the University of California, Berkeley, School of Optometry. Optometric Education. Spring 2001;26(3):83-7.
3. Lakshminarayanan V. Teaching optics in a multi-disciplinary curriculum: experience from optometry programs [Internet]. Proceedings 10th International Topical Meeting on Education and Training in Optics and Photonics; 2007 Jun 3; Ottawa. Bellingham (WA): SPIE; [cited 2019 Sep 9]. Available from: https://www.spiedigitallibrary.org/conference-proceedings--

f-spie/9665/96651D/Teaching-optics-in-a-multi-disciplinary-curriculum–experience-from/10.1117/12.2207538.full?SSO=1
4. Lakshminarayanan V. The human eye: a model system for teaching optics [Internet]. Proceedings of the 11th SPIE Education and Training in Optics and Photonics; 2009 Jun 5; St Asaph, United Kingdom. Bellingham (WA): SPIE; [cited 2019 Sep 9]. Available from: https://spie.org/etop/2009/etop2009_3b.8.75.pdf
5. Maier H, Smith A, Coffey B. A curriculum comparison of U.S. optometry schools: looking back over the decade. Optometric Education. Winter 2005;30(2): 39-55. Available from: //journal.opted.org/files/Volume_30_Number_2_Winter_2005.pdf
6. Putnam NM. Optics in an optometric setting [Internet]. Proceedings of the 14th SPIE Education and Training in Optics and Photonics; 2017; Hangzhou, China; San Francisco, CA: SPIE; [cited 2019 Sep 9]. Available from: https://www.spiedigitallibrary.org/conference-proceedings-of-spie/10452/104521E/Opt-cs-education-in-an-optometric-setting/10.1117/12.2268919.full
7. Thapa D, Lakshminarayanan V. Light and optics conceptual evaluation findings from first year optometry students [Internet]. Proceedings of the 12th SPIE Education and Training in Optics and Photonics; 2014 Jul 17; Porto, Portugal. Bellingham (WA): SPIE; [cited 2019 Sep 9]. Available from: https://www.spiedigitallibrary.org/conference-proceedings--f-spie/9289/928919/Light-and-optics-conceptual-evaluation-findings-from-first-year-optometry/10.1117/12.2070519.full
8. Keating MP. Geometric, physical, and visual optics. 2nd ed. Woburn (MA): Butterworth-Heinemann; c2002. 613 p.
9. Schwartz SH. Geometrical and visual optics: a clinical introduction, 2nd ed. New York (NY): McGraw-Hill Medical; c2013. 369 p.
10. National Research Council. National science education standards. Washington (DC): National Academies Press, c1996. 272 p.
11. Hoftstein A, Lunetta VN. The role of the laboratory in science teaching: neglected aspects of research. Rev Educ Res. 1982;52(2):201-17.
12. Hofstein A, Lunetta VN. The laboratory in science education: foundations for the twenty-first century. Sci Ed. 2004;88(1):28-54.
13. Carini RM, Kuh GD, Klein SP. Student engagement and student learning: testing the linkages. Res High Educ. 2006;47:1-32.
14. Gleason BL, Peeters MJ, Resman-Targoff BH, et al. An active-learning strategies primer for achieving ability-based educational outcomes. Am J Pharm Educ. 2011 Nov10;75(9):186.
15. Powner LC, Allendoerfer MG. Evaluating hypotheses about active learning. Int Stud Perspect. 2008;9(1):75-89.
16. Saeed F. An innovative teaching method for geometric optics using hands-on exercises in a large classroom setting to stimulate engaged learning. Optometric Education. Winter-Spring 2013;38(2):54-9.
17. Spencer AL, Brosenitsch T, Levine AS, Kanter SL. Back to the basic sciences: an approach to teaching senior medical students how best to integrate basic science and clinical medicine. Acad Med 2008;83(7):662-69.
18. Wang L. Developing and evaluating an interactive multimedia instructional tool: learning outcomes and user experiences of optometry students. J Educ Multimed and Hypermed. 2008:17(1):43-57 [cited 2019 Sept 10]. Available from: https://www.learntechlib.org/primary/p/22939/
19. Hunter L, Metevier AJ, Seagroves S, et al. Cultivating scientist- and engineer-educators 2010: the evolving professional development program [Internet]. In: Hunter L, Metevier A, editors. Learning from Inquiry in Practice. Astronomical Society of the Pacific Conference Series; 2010 Jan; Santa Cruz, CA. San Francisco, CA: Astronomical Society of the Pacific; 2011 [cited 2019 Sept 10]. Available from: http://www.aspbooks.org/a/volumes/article_details/?paper_id=32506
20. Putnam NM, Maness HL, Rossi EA, Hunter JJ. An inquiry-based vision science activity for graduate students and postdoctoral research scientists [Internet]. In: Hunter L, Metevier A, editors. Learning from Inquiry in Practice. Astronomical Society of the Pacific Conference Series; 2010 Jan; Santa Cruz, CA. San Francisco, CA: Astronomical Society of the Pacific; 2011 [cited 2019 Sept 10]. Available from: http://www.aspbooks.org/a/volumes/article_details/?paper_id=32523
21. Bryan JA. Assessment results following inquiry and traditional physics laboratory activities. J Col Sci Teach. 2006 Jul-Aug;35(7):56-61.
22. Russell CB, Weaver G. A comparative study of traditional, inquiry-based, and research-based laboratory curricula: impacts on understanding of the nature of science. Chem Educ Res Pract. 2011;12:57-67.
23. Putnam NM, Cheng JY, McGrath EJ, Lai DK, Moth P. Lens inquiry: an astronomy lab for non-science majors at Hartnell Community College [Internet]. In: Hunter L, Metevier A, editors. Learning from Inquiry in Practice. Astronomical Society of the Pacific Conference Series; 2010 Jan; Santa Cruz, CA. San Francisco, CA: Astronomical Society of the Pacific; 2011 [cited 2019 Sept 10]. Available from: http://www.aspbooks.org/a/volumes/article_details/?paper_id=32513
24. Raschke L, Severson S, Seagroves S, Porter J. The COSMOS optics inquiry: an inquiry activity for high school students on geometric optics. [Internet]. In: Hunter L, Metevier A, editors. Learning from Inquiry in Practice. Astronomical Society of the Pacific Conference Series; 2010 Jan; Santa Cruz, CA. San Francisco, CA: Astronomical Society of the Pacific; 2011 [cited 2019 Sept 10]. Available from: http://www.aspbooks.org/a/volumes/article_details/?paper_id=32512

Is Educational Theory of Use in Optometric Education?

Patricia Hrynchak, OD, MScCH (HPTE), FAAO, DipOE | Optometric Education: Volume 45 Number 3 (Summer 2020)

Introduction

Healthcare education is carried out primarily by instructors repeating the way in which they were taught.[1-7] There is a sense that teaching is an art where only content knowledge and natural talent are needed to excel.[3] New trends, such as the "flipped classroom," may be applied without an understanding of the principles behind the educational strategy.[1] If the method fails to achieve desired results, blame is placed on the method.[1] Without an understanding of the theory that underlies newer teaching methods, instructors risk misapplying strategies, which can result in a lack of successful implementation for both teachers and learners.[1,3] It is reasonable to believe that optometric education has similar challenges.

Theory is a conceptual understanding of how things work.[2] The usefulness of theory may be more readily understood from an example from the ocular disease literature. Glaucoma is a common eye disease that can result in permanent vision loss. While the pathogenesis is incompletely understood, a number of theories exist. Theories include vascular (insufficient blood supply due to increased intraocular pressure [IOP]), biomechanical (increased IOP leading to strain of the lamina cribrosa) and biochemical (neurodegeneration from biochemical mechanisms).[8] As well, the role of cerebrospinal fluid is seen as potentially important.[8] These theories were built from an impressive amount of quantitative and qualitative research. The vascular and biomechanical theories are applied by treating glaucoma with IOP reduction. In addition, theories drive research and are modified based on the results of the studies. Challenging the existing paradigm is how progress is made. The same principles apply to optometric education.

When research is not based in theory, the results can be misleading. To make a point about the dangers of post hoc analysis of data, Emily Chew performed an analysis of the age-related macular degeneration data from the Age Related Eye Disease Study to show that vitamin and mineral supplementation effectiveness depended upon the zodiac sign of the subject.[9] This was intended to be an obviously incorrect result because zodiac sign is not included in the theories of the pathogenesis of age-related macular degeneration. Similarly, if optometric education research is carried out without attention to underlying educational theory, the results may not have merit.

How people learn is also incompletely understood. There are many theories (based on extensive research) of how people learn and they may be grouped by discipline, such as bioscience, education/learning or sociocultural perspectives.[2] Each theory in itself is only a partial explanation of how learning occurs and many have overlapping concepts.[2] Therefore, when creating an optometric educational plan it is necessary to look to multiple disciplines and their theories to illuminate each aspect of the plan and focus on what is likely to be useful. Theory helps form a scaffold upon which good instruction can be built and allows instructors to understand why and under what circumstances certain practices are successful.[3] The informed optometric instructor, therefore, is less likely to deviate from the model. Also, teaching based in theory, as in the ocular disease example, can be studied, which leads to modifications in the theory and enhanced educational outcomes.[3]

This paper examines some of the theories of learning that might be useful to optometric educators and shows how they can be applied to designing a skills curriculum.

Theories of How Learning Occurs

Theories that aim to explain how learning occurs include the following.

Theories in bioscience focus on how the brain learns.[2] Because discovery comes from science, it is sometimes easy to forget that these are theories and not truth.[2] Neuroscience studies learning and memory formation looking at structure and molecular and cellular function of the brain and has used functional magnetic resonance imaging studies to understand cognition in humans.[10,11] This research has allowed for some general principles to be developed that can be applied in optometric education. These include:[11]

- allow for repetition of material from varying perspectives
- go deeper rather than touching superficially on many topics
- reward and reinforce (this is vital)
- actively engage the learner

- create a moderate stress level for the learner
- allow for adequate rest
- integrate multimodal (auditory and visual input) information rather than expect multitasking

Motor control theories are useful in learning skills such as automaticity and skill expertise (performance is automatized with practice allowing for attention to other factors), deliberate practice (deliberate practice is needed to achieve excellence), and challenge-point framework (learning is maximized when the task is within the ability of the learner and complexity is gradually increased with experience).[2,12]

Education/learning theories can be categorized into five additional orientations: behaviorist, cognitivist, humanist, constructivist and social theories of learning.[13] In the behaviorist view, learners are passive and a stimulus produces a reaction in the learner.[13] Therefore, giving people feedback to allow them to change their behavior is central in this theory.[13] In the cognitive view, learners think about the information, process it and act upon it in different ways depending on the situation.[14] This orientation has produced theories of clinical reasoning, theories on the development of expertise and cognitive load theory.[14] In the humanist perspective people try to achieve their maximal potential.[13] The concepts of self-regulation, self-directed learning and self-assessment align with this orientation.[13] Constructivist learning theory is a refinement of cognitive learning theory and is derived from constructivist epistemology where the "focus is on the mental representation of information by the learner."[15] The learner reconstructs long-term memory representations to be consistent with new information from the environment and experience.[15] For this to occur, learners must process the new material and integrate it with existing understandings to form a new cognitive structure that is unique to them based upon their own process of learning.[16]

Social cognitive theory was formed by blending the behaviorist approach, which emphasizes the importance of the environment on behavior, with the cognitive approach, which emphasizes the importance of cognition on learning and functioning.[13] Learning is seen as a social process with reciprocal interaction between environmental, personal and behavioral determinants.[13] Each of these determinants influences the others with varying outcomes depending on the dominant factor.[13] In this theory humans have five capabilities:[17]

- *symbolizing capability* allows us to use symbols internally to represent actions so we don't have to carry out each action to determine the outcome
- in *forethought capability* we can anticipate the likely outcomes of our behavior so we can plan for those outcomes
- *vicarious capability* allows us to learn by observing others
- *self-regulatory capability* allows us to regulate our behavior by our internal standards
- *self-reflective capability* allows us to look critically at our experiences and think about our thought processes[17]

In situated learning theory, learning is seen as a socio-cultural process tied to context with its social relations and practices.[13] The term *communities of practice* describes the activities of a group of people with a shared interest.[13] In *legitimate peripheral participation*, learners start at the periphery of the community by observing and performing simple tasks and then gradually move more centrally assuming the roles, skills, norms and values of the culture as an active participant.[13] Learning occurs in the workplace from an individual and social perspective.[13] In the related concept of experiential learning, learning occurs through reflection on experience in practice.[13] Reflection is an important concept that is seen in multiple theories of learning.[13]

Application to a Curriculum Element

How can any of these theories be applied in optometric education? As an example, optometric educators may be tasked with reviewing the psychomotor skills curriculum of their school or college. It would behoove them to look to best practices in healthcare education and understand the theoretical underpinnings when designing the program. **Table 1** summarizes the design elements that could be used to develop a procedural skills stream in the curriculum renewal process. The theoretical basis supporting the design element is given as is an example of how it can be operationalized. Assessment methods are also reviewed.

TABLE 1
Design Elements and Their Theoretical Basis for Learning Procedural Skills

Design Element	Theoretical Basis	Example of Operationalization
1. **Development of clear required outcomes**	Social cognitive theory (forethought capability)	Write clear learning objectives
2. **Demonstration of procedure and task-relevant knowledge**	Social cognitive theory (vicarious capability and self-efficacy); constructivism; cognitive load	Use online learning methods to deliver the relevant knowledge ahead of the skills session. Demonstrate the skill using Peyton's Four-Step Approach.[19]
3. **Longitudinal, repetitive and progressive skill development**	Motor control theory; deliberate practice	Lab training should allow for repeated practice in episodes of short duration until the skill is automatized. This is followed by progressive exposure to more difficult conditions.
4. **Guided practice with distributed feedback**	Social cognitive theory (self-efficacy, self-regulation and self-evaluation); reflection	Specific formative feedback during the lab training by instructors is essential. This should continue to occur in clinical practice.
5. **Transfer of skills to a real practice setting with a cultural milieu consistent with real practice**	Situated learning; legitimate peripheral participation	Plan for early clinical exposure (in the first year) with observation progressing gradually to assisting in practice and then to direct one-on-one patient care.

Table 1. *Click to enlarge*

Development of clear outcomes or goals enhances learning by allowing the learner to develop strategies to reach the goal and is based in social cognitive theory.[18] In social cognitive theory, learners are active agents and learning is influenced by their personal goals, values, attitudes, knowledge and experience.[18] Once the goals are articulated to them, learners are able to take on the goals and monitor their progress towards the goals.[13] Humans are able to anticipate the likely outcomes of actions, and this forethought, as a capability, helps in achievement of goals under this theory.[17] Teachers need to support learners in regulating their own learning.[3] This is operationalized by writing learning objectives.[17] Learning objectives are clear statements of what ability the learner will have at the end of the educational session. For example, "At the end of this course the student will be able to perform retinoscopy on a normal adult person and obtain a result within the repeatability of the technique."

Demonstration of the skill and providing task-relevant knowledge gives learners the foundation for building their abilities and increases self-efficacy. In social cognitive theory, as described by Kaufman and Mann, learners construct meaning by observing others in a social context.[17] This produces a standard of performance against which they can judge their own performance. They need to understand the task and build on prior knowledge, which has a constructivist underpinning. However, they may need help in activating that prior knowledge and relating it to the new learning.[17] Operationalization can be using online learning methods to allow for developing task-relevant knowledge without using allocated lab time. Peyton's Four-Step Approach to teaching a skill has been shown to produce higher ratings on a global rating scale for a skill assessment than the standard approach of demonstration with explanation followed by answering questions.[19] In this approach the instructor first demonstrates the skill without comment, which decreases cognitive load. Next, the instructor demonstrates the skill while describing the skill in detail. This is followed by the student talking the instructor through the skill. Finally, the student performs the skill on his/her own.[19] Step 3 has the most impact on learning the skill.[20]

Longitudinal, repetitive, progressive skill development is based on bioscience theory of motor control such as the Fitts and Posner model of automaticity in which well-learned skills become automatic with practice.[2] Ericsson's idea of deliberate practice to develop expertise requires lengthy, repetitive and dispersed domain-specific practice.[12] Challenge-point framework states that an optimal challenge point exists when learning is maximized and detriment to performance is minimized.[2] That is, the difficulty of the task is matched to the learner's abilities.[2] To operationalize these concepts, skill training should start in a laboratory setting where the students practice on themselves. Ideally, the sessions should be timed to one or two hours and repeated frequently. Introduction to more complex scenarios would occur during clinic rotations in primary care and then in specialty care settings.

Guided practice with distributed feedback is based upon the aspects of social cognitive theory that state that individuals develop positive self-efficacy through practice with positive feedback. The feedback should be constructive because without it performance achievement is reduced. Feedback is also helpful because it provides information the individual can use in reflective practice.[17] This aspect is vital to the learning process. Indeed, the ability to self-assess is tied to the ability to reflect on practice.[13] As described by Mann, to operationalize this the learner should be provided with immediate error correction while performing the procedure but limited verbal guidance and coaching. This is because the coaching takes the learner's attention away from the task, overloads working memory and the learner may become reliant on the educator to compete the task. Then, at the end of the skill performance, feedback is provided. According to Nicholls et al., "Feedback is the single most influential teaching practice to promote motor learning."[21] Feedback should continue to occur in the clinical setting and be based on direct observation.[22]

The elements of *transfer of skills to a clinical setting* with a cultural milieu consistent with real practice and gradual transition to independent practice with initial observation are grounded in the concepts of situated learning, communities of practice and

legitimate peripheral participation.[13] Inherent in these concepts is the idea that learning is tied to its context, social relations and practice.[13] The community of practice is a group of people who pursue a shared enterprise.[13] Initially novices participate peripherally (for example by observation) and then gradually move more centrally when they gain the skills, norms, values and culture of the community.[13] To operationalize this theory optometric students should be observing in clinic during early years of optometric education. Then they may progress to assist with skills such as pre-testing and subsequently move on to assisting with examinations before they are competent enough to conduct skills independently. This can happen concurrently with laboratory practice.

Assessment

Assessment should be aligned with the learning objectives of the procedural skills training program. Learning objectives are what the learner is to achieve, while learning outcomes are what the learner did achieve. Miller's framework (pyramid) for clinical assessment **(Figure 1)** describes four levels of ability: knows (knowledge), knows how (competence), shows how (performance), does (action).[23] Consistent with Miller's pyramid, a system of assessment should be in place that addresses each level in the pyramid.[23] Written examinations such as multiple-choice questions or long-answer questions can be used to assess the concepts behind the procedures for the "knows" and "knows how" components.[24] Direct observation of the procedures using checklists as the procedures are performed in the lab and a summative pre-clinical competency examination are at the level of "shows how."[24] Direct observation of optometric skills in clinic can be used for the "does" level.[24] In addition, students should be encouraged to keep logbooks for procedures and write reflective e-portfolios to encourage self-assessment and self-directed learning.

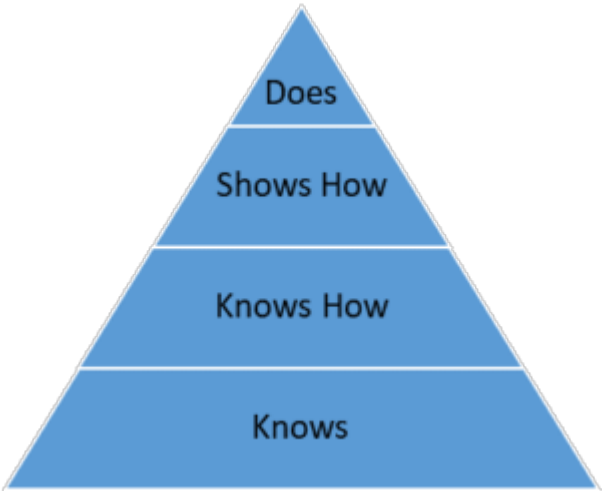

Figure 1. *Miller's pyramid of clinical assessment.*[23]
Click to enlarge

Conclusion

This paper presents a variety of theories as lenses through which to view optometric education. Each theory illustrates an aspect and allows us to focus on a goal in education to address it more effectively. Some theories are more relevant to a particular educational problem than others. The theories in this paper are not exhaustive of those in the literature; they represent only a sample. Ultimately, theories are challenged through research, which allows for development and improvement over time. An example from general education is the popular theory of learning styles has been disproven through research in application of the theory to teaching and learning.[25] A research question pertaining to the skills training example could be "Does using Peyton's Four-Step Approach to teaching a skill improve performance on skills assessment?" This could be studied using a randomized controlled trial design in which traditional teaching is done in one lab section, Peyton's approach is done in another, and the skills assessment results are compared.[26]

Educational theory allows both educators and learners to develop a perspective and discourse around best practices. The discourse of a discipline provides a language for representing its work and allows for discussion and reflection.[13] It behooves us as optometric educators to challenge ourselves to become familiar with the relevant theories of healthcare education, to apply them in our work and study the results. This will move us toward the important goal of creating a culture of using theory-informed approaches in optometric education.

References

1. Kamel-ElSayed S, Loftus S. Using and combining learning theories in medical education. Med Sci Educ. 2018;28(1):255-258.
2. Hodges BD, Kuper A. Theory and practice in the design and conduct of graduate medical education. Acad Med. 2012; 87(1):25-33.

3. Artino AR Jr, Konopasky A. The practical value of educational theory for learning and teaching in graduate medical education. J Grad Med Educ. 2018 Dec;10(6):609-613.
4. Torre DM, Daley BJ, Sebastian JL, Elnicki DM. Overview of current learning theories for medical educators. Am J Med. 2006 Oct;119(10):903-7.
5. McLeod P, Steinert Y, Chalk C, et al. Which pedagogical principles should clinical teachers know? Teachers and education experts disagree. Disagreement on important pedagogical principles. Med Teach. 2009 Apr;31(4):e117-24.
6. McLeod PJ, Steinert Y, Meagher T, McLeod A. The ABCs of pedagogy for clinical teachers. Med Educ. 2003 Jul;37(7):638-44.
7. Zackoff MW, Real FJ, Abramson EL, Li ST, Klein MD, Gusic ME. Enhancing educational scholarship through conceptual frameworks: a challenge and roadmap for medical educators. Acad Pediatr. 2019 Mar;19(2):135-141.
8. Wostyn P, De Groot V, Van Dam D, Audenaert K, Killer HE, De Deyn PP. The glymphatic hypothesis of glaucoma: a unifying concept incorporating vascular, biomechanical, and biochemical aspects of the disease. Biomed Res Int. 2017:5123148.
9. Chew EY, Klein ML, Clemons TE, Agrón E, Abecasis GR. Genetic testing in persons with age-related macular degeneration and the use of the AREDS supplements: to test or not to test? Ophthalmology. 2015;122(1):212-5.
10. Fields RD. Imaging learning: the search for a memory trace. Neuroscientist. 2011;17(2):185-96.
11. Friedlander MJ, Andrews L, Armstrong EG, et al. What can medical education learn from the neurobiology of learning? Acad Med. 2011;86(4):415-20.
12. Ericsson KA. Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. Acad Med. 2004 Oct;79(10 suppl):S70-81.
13. Mann K. Theoretical perspectives in medical education: past experience and future possibilities. Med Ed. 2011;45(1):60-68.
14. Mohanna K. Teaching made easy: a manual for health professionals (3rd ed.). New York: Radcliffe Publishing. 2010.
15. Svinicki MD. Learning and motivation in the postsecondary classroom. San Francisco: Anker Pub. Co. 2004.
16. Moon JA. A handbook of reflective and experiential learning: theory and practice. New York: Routledge. 2004.
17. Kaufman D, Mann K. Teaching and learning in medical education: how theory can inform practice. In T. Swanwick (Ed) 2nd Ed. Understanding medical education: evidence, theory and practice. London: Willey-Blackwell. 2014.
18. Harris I. Chapter 3: Conceptions and theories of learning for workplace education. In J. Hafler (Ed) Extraordinary learning in the workplace. New York: Springer. 2011.
19. Krautter M, Weyrich P, Schultz JH, et al. Effects of Peyton's Four-Step Approach on objective performance measures in technical skills training: a controlled trial. Teach Learn Med. 2011;23(3):244-50.
20. Krautter M, Dittrich R, Safi A, et al. Peyton's Four-Step Approach: differential effects of single instructional steps on procedural and memory performance – a clarification study. Adv Med Educ Pract. 2015;6:399-406.
21. Nicholls D, Sweet L, Muller A, Hyett J. Teaching psychomotor skills in the twenty-first century: revisiting and reviewing instructional approaches through the lens of contemporary literature. Med Teach. 2016;38(10):1056-1063.
22. Kogan JR, Holmboe ES, Hauer KE. Tools for direct observation and assessment of clinical skills of medical trainees: a systematic review. JAMA. 2009 Sep 23;302(12):1316-26.
23. Miller GE. The assessment of clinical skills/competence/performance. Acad Med.1990;65(9 suppl):S63-7.
24. Ramani S, Leinster S. AMEE Guide no. 34: Teaching in the clinical environment. Med Teach. 2008;30(4):347-64.
25. Cuevas J. Is learning styles-based instruction effective? A comprehensive analysis of recent research on learning styles. Theory and Research in Education. 2015 Nov;13(3):308-333.
26. Boet S, Sharma S, Goldman J, Reeves S. Review article: medical education research: an overview of methods. Can J Anesth. 2012;59(2):159-170.

SCCOMBKU Graduate is Winner of 2020 Student Award in Clinical Ethics

| Optometric Education: Volume 45 Number 3 (Summer 2020)

Ryan Yuan, OD

ASCO and its Ethics Educators Special Interest Group are pleased to announce Ryan Yuan, OD, as the winner of the 2020 Student Award in Clinical Ethics. Dr. Yuan graduated this year from Southern California College of Optometry at Marshall B. Ketchum University. His winning essay, "Ethics of Ocular Pain Management," appears below.

The Student Award in Clinical Ethics competition, sponsored by Alcon, is open to optometry students during any point in their professional program at an ASCO-affiliated school or college of optometry.

The winner receives an engraved plaque and $1,000. ASCO thanks all the students who submitted essays.

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Ethics of Ocular Pain Management

By Ryan Yuan, OD

Case Description

RR is a 55-year-old Native American male with a complicated ocular history. Diagnosed at an early age with keratoconus, he underwent penetrating keratoplasty OU in 2012. He later contracted bacterial and fungal keratitis on the corneal grafts and developed secondary steroid-induced glaucoma, which was managed with tube shunts OU. In 2018, he experienced blunt force trauma OS, which caused corneal wound dehiscence, displacement of his posterior-chamber intraocular lens, and a retinal detachment. After open-globe repair, RR was prescribed scleral contact lenses OU; however, the poor fit of the lenses caused mechanical exposure of the tube shunt OD over time. Endophthalmitis caused by methicillin-resistant *Staphylococcus aureus* eventually developed OD, and the condition progressed to a blind, painful, hypertensive eye. RR had been treated most recently with diode cyclophotocoagulation and retrobulbar chlorpromazine to manage the pain.

RR's medical history is remarkable for opioid abuse. According to his hospital records, RR had been prescribed 19 pain medications from 16 different providers over the years. He presented to our clinic asking for specific medication to alleviate the pain from his phthisical, hypertensive right eye. Given his ocular treatment history and prior opioid use, what ethical factors should be evaluated prior to initiating therapy?

Ethics Considerations

Optometrists are held to an ethical standard that requires morally responsible prescribing. For those with the relevant credentials, should opioids be prescribed to a patient with a history of misuse? Are there long-term consequences that need to be assessed? Should his request for treatment affect the clinical decision-making? Is there an optometric standard of care that can be applied?

The Opioid Epidemic

In 2018, the Centers for Disease Control and Prevention (CDC) estimated that more than 10 million people in the United States age 12 years and older reported misuse of prescription opioids.[1] It has also been estimated that more than 47,000 deaths, or nearly 129 deaths per day, from opioid overdose occurred in 2017.[1] Examples of opioids include, but are not limited to, natural opioids (morphine, codeine), semi-synthetic opioids (hydrocodone, oxycodone) and synthetic opioids (fentanyl, tramadol).

Few ocular conditions warrant opioid use; however, opioids may be prescribed for post-operative refractive surgery pain and can be considered in serious cases of ocular trauma, endophthalmitis, corneal hydrops or neovascular glaucoma. Credentialed optometrists who hold a Drug Enforcement Administration (DEA) license are limited in the type and quantity of opioids they can prescribe. Their role in the opioid epidemic remains to be seen. Nevertheless, any physician with the ability to prescribe potentially addictive and fatal medications must prescribe with ethical considerations in mind.

Optometric Values

Like all healthcare providers, optometrists abide by codes of ethics and values that are reminiscent of the historical Hippocratic Oath; namely, the principles of *beneficence, non-maleficence, autonomy and justice*.

Beneficence: The "do good" principle entails that the optometrist must take actions that are in the best interest of patients and their families. On the surface, it seems easy to apply in the everyday life of optometrists as they adhere to the optometric standard of care with refractions, ocular health examinations and the sale of ophthalmic devices with the goal of providing right and excellent care. Probing deeper, however, the optometrist must ask how to "do good" as it relates to pain management, such as in the case of RR. Utilizing the knowledge of ocular pathophysiology and the corresponding therapeutic options, the optometrist must weigh the risks and benefits of each modality. Would it be beneficial not to prescribe medication to RR? He has a legitimate reason for pain, but would his pain abate with over-the-counter oral analgesics, or does it warrant a prescription for oral opioids?

Non-maleficence: The optometrist may have good intentions in prescribing; nevertheless, a second layer of ethical consideration requires him/her to assess whether the prescribed treatment would cause harm, either immediately or in the future. It is well-known that physical dependence can form when opioids are used regularly, and the DEA ranks controlled substances (I-V) based on potential for abuse. Hydrocodone, specifically, was a widely used Schedule-III drug that was moved to Schedule II in 2014 due to higher addictive properties.[2] In most states, DEA-licensed optometrists can prescribe Schedule III-V drugs. Specific conditions for Schedule II allow optometrists to continue prescribing hydrocodone. Though the immediate effects of opioids would bring pain relief, long-term use has been linked to increased tolerance, depression and risk of death related to overdose.[3]

Given RR's long history of opioid misuse, would prescribing cause him long-term harm? Do the benefits of opioid treatment today outweigh possible future risk? By not prescribing, will he become more volatile in his behavior and drug-seeking tendencies?

Autonomy: Because RR specifically requested pain medication for his ailment, the principle of patient autonomy presents. According to this doctrine, the optometrist must regard the patient's requests when it comes to treatment options; that is to say, to a certain extent. If a patient requests medical treatment when there are no clinical findings to justify medication, the optometrist should not oblige just to satisfy the patient's wishes. The doctor's clinical judgment must be respected in all patient-doctor relationships. On the other hand, the optometrist ought to be morally responsible by informing and including the patient in all treatment decisions.

Is it ethical to refrain from presenting opioids as a treatment option if there is potential for drug abuse? What if the patient's wishes differ from the optometrist's desired treatment? Medical paternalism is an exception to patient autonomy in cases involving young children or the mentally incompetent. Could it be argued that RR is not fully competent in his decision-making due to his addictive tendencies?

Justice: Philosophically, justice typically asks who to "save" given hypothetical scenarios of scarce resources and patients suffering from differing levels of morbidities. In the context of optometry, justice can be applied instead as the duty of the optometrist to treat all patients fairly and ethically. Optometrists must adhere and apply to the relevant standards of care accordingly. In cases such as RR, there are no customary opioid-related treatment recommendations. In fact, the Wills Eye Manual only mentions opioids in the treatment of chemical burns, band keratopathy and dacryocystitis.[4] The CDC and American Optometric Association provide loose guidelines for prescribing and propose that an opioid prescription of three days or less will be sufficient for most conditions.[5,6] From this it can be inferred that opioid prescriptions should be considered on a case-by-case basis as not all situations are the same.

Would it be ethical to refer the patient to another provider who may be more qualified to handle his type of care? If RR was a personal family member, would the level and method of care be handled any differently?

Conclusion

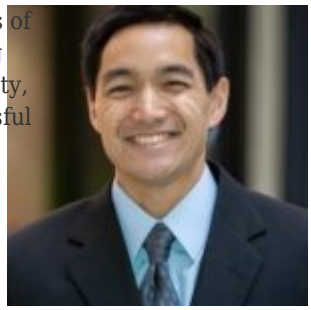
All things considered, RR's case was co-managed with an ophthalmologist, and it was decided that prescribing a five-day supply of Tylenol 3 (which contains acetaminophen and codeine) would be both beneficent and justified. RR, on the other hand, quickly reported that Tylenol 3 would not be strong enough for his pain. The ophthalmologist then recommended another retrobulbar injection of chlorpromazine. Chen et al. reported that retrobulbar chlorpromazine is an effective analgesic with an efficacy lasting from three months to a year.[7] This treatment option would protect RR from potential opioid abuse, and the dialogue allowed RR to have a say in his medical care. However, the fact that RR recently had a retrobulbar procedure and still reported pain reflects the reality that 33% of patients with retrobulbar chlorpromazine treatments may need alternative interventions to manage pain.[8] With RR's ocular history and current condition, the last treatment option discussed was enucleation for his phthisical eye. Idowu et al. reported that long-term pain relief and discontinuation of oral analgesics was achieved in 100% of patients with enucleated or eviscerated eyes.[9] It remains to be seen whether this treatment would provide RR with the lasting pain relief he seeks. Nevertheless, the next ethical issue at hand should be addressing his drug-seeking tendencies.

References

1. Centers for Disease Control and Prevention. 2019 annual surveillance report of drug-related risks and outcomes – United States surveillance special report. Centers for Disease Control and Prevention, U.S. Department of Health and Human Services. Published Nov. 1, 2019. [Accessed June 15, 2020]. Available from: https://www.cdc.gov/drugoverdose/pdf/pubs/2019-cdc-drug-surveillance-report.pdf
2. DEA to publish final rule rescheduling hydrocodone combination products [Aug. 21, 2014]. Washington, DC: Cote Law PLLC, DEA Chronicles; c2020 [accessed Feb. 5, 2020]. Available from: https://www.deachronicles.com/2014/08/dea-to-publish-final-rule-rescheduling-hydrocodone-combination-products/
3. Salsitz E, Wiegand T. Pharmacotherapy of opioid addiction: "putting a real face on a false demon." J Med Toxicol. 2016 March;12(1):58-63. doi:10.1007/s13181-015-0517-5.
4. Bagheri N, Wajda BN, Calvo CM, Durrani AK, Friedberg MA, Rapuano CJ. The Wills Eye Manual Office and Emergency Room Diagnosis and Treatment of Eye Disease. 7th ed. Philadelphia: Wolters Kluwer; 2017.
5. CDC guideline for prescribing opioids for chronic pain. Centers for Disease Control and Prevention. Accessed Feb. 5, 2020. Available from: https://www.cdc.gov/drugoverdose/prescribing/guideline.html
6. Opioid crisis – U.S. public health emergency: recommendations for doctors [Nov. 2017]. Health Policy Institute American Optometric Association. [accessed Feb. 4, 2020]. Available from: https://www.aoa.org/documents/HPI/The%20Opioid%20Public%20Health%20Emergency%20and%20How%20Doctors%20of%20Optometry%20Can%20Help.pdf
7. Chen TC, Ahn Yuen SJ, Sangalang MA, Fernando RE, Leuenberger EU. Retrobulbar chlorpromazine injections for the management of blind and seeing painful eyes. J Glaucoma. 2002 Jun;11(3):209-13. doi:10.1097/00061198-200206000-00008.
8. Galindo-Ferreiro A, Akaishi P, Cruz A, et al. Retrobulbar injections for blind painful eyes: a comparative study of retrobulbar alcohol versus chlorpromazine. J Glaucoma. 2016;25(11):886-890. doi:10.1097/IJG.0000000000000473.
9. Idowu OO, Ashraf DC, Kalin-Hajdu E, Ryan MC, Kersten RC, Vagefi MR. Efficacy of care for blind painful eyes. Ophthalmic Plast Reconstr Surg. Mar/Apr 2019;35(2):182-186. doi:10.1097/IOP.0000000000001205.

The Idea of Teaching as a Way to “Give Back”

Jason S. Ng, OD, PhD, FAAO | Optometric Education: Volume 45 Number 3 (Summer 2020)



Jason S. Ng, OD, PhD, FAAO

As an interviewer of prospective students and prospective faculty members, I hear many mentions of “giving back” with regard to an optometric teaching career. Prospective students often cite giving back as the reason they want to eventually teach after a clinical practice career. Prospective faculty, particularly individuals transitioning from private practice or industry, often speak of how successful they’ve been and that they’re now ready to give back. It seems as if applicants expect such statements to result in a positive evaluation, but it isn’t clear to me why this should be the case.

The Way I See It

I suppose I can assume applicants who want to give back by teaching are acknowledging that teachers invest themselves in their students rather than in only themselves. They “pay it forward” and give back the time, knowledge and experience they “took from” their teachers who were giving back to them in the first place. However, in my opinion, teaching is an art, a science and a form of service. While optometric educators are constantly giving back — to our institutions, to our colleagues, and of course to the students whose lives we touch — teaching is more than that. For me, entering the teaching profession was more about making a difference than giving back. The passion and energy of my best teachers opened my mind to teaching as a profession. Like many, I’ve had great teachers and I’ve had terrible teachers. Having had both types, especially in my undergraduate studies, I experienced firsthand the difference a terrific teacher can make and this inspired me even more to want to make a difference as a teacher. I wanted to be one of the great ones because I didn’t want students to suffer through the opposite experience.

To me, working towards being the best teacher I can be is not easy. Rather, it’s an intimidating, difficult, life-devoting and never-ending process. Perhaps that’s why “I would like to give back now by starting a teaching career” sounds to me like an assumption that a great clinician and/or practice manager is automatically a great teacher. “See one, do one, teach one” comes to mind. Professionals who have done great things outside of teaching can probably “teach one.” But can they do so at an exceptional level? I don’t think the ability to give back in that way comes that easily to most, no matter how exceptional their abilities in clinical practice or elsewhere.

What I’d Rather Hear

Prospective faculty members who have never taught may be innocently ignorant of the rigors of teaching. Therefore, I don’t think they should rest their passion for embarking on a teaching career solely on a statement about giving back. I want them to say more about why they want to teach. I want them to say more about why teaching excites and inspires them. I want them to say more about how they want to be an exceptional teacher and not just a teacher. I want them to focus on how to best help students, both high and low performers. I want them to ask about teaching resources. I want them to ask about faculty development. I want to see a fire in them and come away with the impression they’ll be an active colleague in helping to shape the teaching persona of the college/university. I want them to focus on the students, the faculty, the institution and not necessarily only on their own feeling of giving back.

Maybe this is too much to expect from applicants who haven’t experienced the highs and lows of teaching or had time to develop a true passion for it. Maybe the thought of giving back is a sufficient place to start, but an open mind is crucial as well. I believe the most successful mindset is that teaching is a unique and challenging profession; success in one aspect of the field doesn’t guarantee success as a teacher; and it takes a lot of work to develop into a great teacher. Furthermore, we never really “make it” in teaching because it’s constantly evolving, all while we continue to fulfill our commitments of giving back to our students, peers, mentors, institutions and ourselves.

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

| Optometric Education: Volume 45 Number 3 (Summer 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**

For more information, e-mail journal Associate Editor Keshia S. Elder, OD, MS, FAAO, or journal Editor Aurora Denial, OD, FAAO.

MEWDS: a Teaching Case Report

Crystal Lewandowski, OD, FAAO, and Daniel Bastian, OD, FAAO | Optometric Education: Volume 45 Number 3 (Summer 2020)

Background

This case involves a 22-year-old Caucasian female diagnosed with multiple evanescent white dot syndrome (MEWDS). MEWDS is part of a group of inflammatory disorders known as white dot syndromes, which affect the retina, retinal pigment epithelium (RPE) and choroid.[1] Often, symptoms of MEWDS are unilateral, have sudden onset, and include blurred vision, central or paracentral scotomas, enlarged blind spots, photopsia or dyschromatopsia. Observable ocular signs include multiple small, gray-white spots at the level of the RPE and outer retina. The most significant consequence of MEWDS is temporary vision changes, which usually spontaneously revolve. However visual field defects and photopsias may persist.[1-4] This teaching case report highlights the role of the primary care optometrist in the evaluation and management of MEWDS. It focuses on the importance of critical-thinking skills for accurate diagnosis as well as patient education. It is appropriate for use with optometry residents and students who have had some patient care experience and knowledge in ocular disease. At most colleges, it would be appropriate for third- and fourth-year optometry students.

Student Discussion Guide

Case description

Visit 1

A 22-year-old Caucasian female was referred by her primary care physician to the vision department as a new patient for same-day evaluation. She complained of a gray spot in her vision in her left eye, associated with blur and loss of vision in part of her visual field. She denied new flashing lights, movement of the "spot" throughout her visual field, new floaters, new headache, eye pain and sun-gazing. At her last eye exam with a different doctor 10 months prior, the patient reported an unremarkable ocular history and that she didn't wear glasses or contact lenses. Her medical history was remarkable for seasonal allergies, migraines with aura, irritable bowel syndrome and a recent history of flu a few days before onset of vision changes. She did not experience symptoms of nausea or vomiting at the time of her reported flu. Her medications included birth control pills as well as Dayquil and acetaminophen at the time of flu. There were no known medication allergies.

TABLE 1
Anterior and Posterior Segment Evaluation

	Right eye	Left eye
Lids/lashes	clear	clear
Conjunctiva	white, quiet	white, quiet
Cornea	clear, no scar	clear, no scar
Anterior chamber	deep, quiet, no cells, no flare	deep, quiet, no cells, no flare
Iris	flat	flat
Lens	clear, no opacity	clear, no opacity
Vitreous	clear, no cells	clear, no cells
Optic nerve	distinct margins, pink rim, 0.30 h/v c/d ratio	distinct margins, pink rim, 0.30 h/v c/d ratio
Macula	flat	faint, fine granular change nasal to fovea
Posterior pole	clear	clear
Periphery	flat without retinal breaks 360°	flat without retinal breaks 360°

Table 1. *Click to enlarge*

Uncorrected distance visual acuity (UCDVA) was 20/20 in each eye. Pupils, extraocular muscles and finger-counting confrontation fields were normal. Intraocular pressure was 16 mmHg in each eye. Undilated exam showed normal ocular health in each eye. The patient's pupils were dilated with 1% tropicamide and 2.5% phenylephrine, and a 24-2 Sita Fast full-threshold automated Humphrey visual field (HVF) test was ordered for the patient to complete while dilating. After dilated retinal evaluation, optical coherence tomography (OCT) of the macula was ordered. **Table 1** shows slit lamp findings and dilated fundus evaluation; **Figure 1** shows HVF test results; and **Figure 2** shows the OCT macular imaging.

The patient was diagnosed with central scotoma in the left eye secondary to MEWDS. She was shown her HVF and OCT test results and educated about MEWDS. The vision team explained that there are no treatment options for MEWDS and that symptoms should self-resolve without intervention. The patient was reassured that there were no signs of anterior or posterior segment inflammation, optic neuropathy or retinal breaks that would require treatment and that she'd be monitored closely for any changes. A two-week follow-up visit was recommended, and the patient was given an Amsler grid for monitoring her vision at home. She was offered the option of being

evaluated by a retinal specialist at the two-week visit. She agreed and the referral was made.

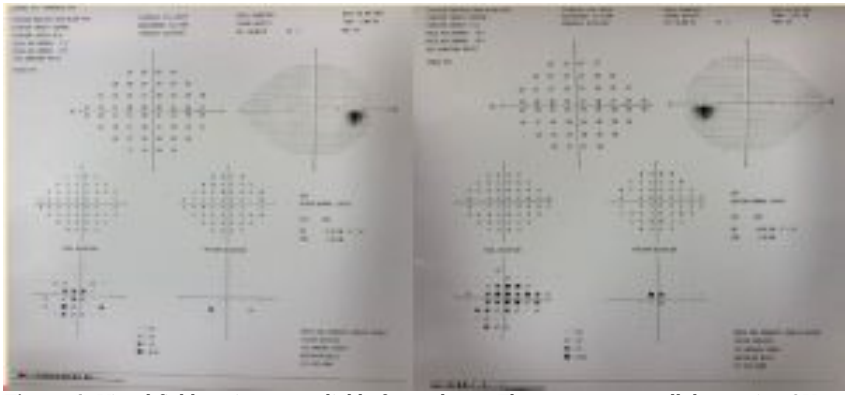


Figure 1. *Visual field testing was reliable for each eye. There was an overall depression OU and central scotoma OS, without neurological defects.*
Click to enlarge

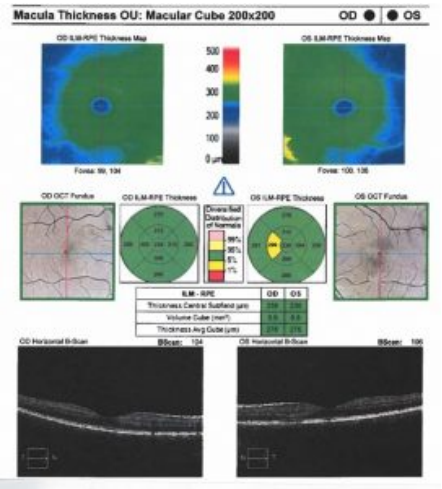


Figure 2. *OCT testing revealed disruption in the photoreceptor integrity line inferior-nasal to the fovea with normal foveal contour and without intra- or sub-retinal fluid.* *Click to enlarge*

Visit 2: one-day follow-up

Rather than wait for the two-week follow-up visit, the patient chose to be evaluated the next day by a retina specialist, who repeated dilated fundus evaluation with OCT and performed fluorescein angiography (FA). OCT findings were described as normal in the right eye, and ellipsoid zone disruption inferior to the fovea was observed in the left eye. On FA, there were no observable hyperfluorescent retinal lesions in either eye, confirming the absence of underlying vasculitis, leakage or optic nerve inflammation, ruling out several other potential white dot syndromes. Based on a granular macular appearance, OCT results and documented central scotoma, the ophthalmologist confirmed the diagnosis of MEWDS. The relevant patient education was delivered again: There are no proven treatments for MEWDS; it usually resolves on its own over several weeks; and, in the absence of underlying inflammation, follow-up in two weeks was an appropriate course of action.

Visit 3: two-week follow-up

The patient returned to the ophthalmology department for the two-week progress evaluation. Dilated examination showed stable ocular health and OCT findings. Continued monitoring with a follow-up examination in two months was recommended, but the patient was lost to follow-up.

Educator's Guide

The Educator's Guide includes the necessary information for teaching and discussing the case.

Key concepts

1. Hallmark symptoms and signs of MEWDS
2. Critical-thinking skills in diagnosis, using appropriate optometric tools when additional testing may guide to a diagnosis
3. Management and clinical course of MEWDS
4. The role of communication throughout the exam: developing patient rapport, obtaining a thorough case history, patient education

Learning objectives

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

1. Describe the ocular signs of MEWDS
2. Apply critical-thinking skills to correlate symptoms with clinical findings
3. Describe various white dot syndromes, noting similarities and differences to MEWDS

4. Describe additional testing that can be performed to confirm the diagnosis of MEWDS
5. Understand the need to investigate further if the clinical picture does not match the patient's complaints

Discussion questions

A. Knowledge, concepts, facts, information required for critical review of the case:

1. Describe classic presentation of MEWDS and compare to other white dot syndromes
2. Determine differential diagnoses by analyzing case history, risk factors and demographics
3. Describe MEWDS etiology and patient demographics
4. Discuss how recent flu impacted this case

B. Differential diagnosis:

1. What tests were used in this case to diagnose MEWDS?
2. What are differential diagnoses based on symptoms alone?
3. How were the clinical findings analyzed to rule out or support potential differential diagnoses?
4. At this time, are there other diagnoses one should consider?

C. Patient management and the role of the optometrist:

1. What are appropriate management options in this case?
2. What is an appropriate follow-up schedule?
3. What is the prognosis for a patient with MEWDS?
4. What are patient education strategies to reassure patients when their condition is self-limiting and/or no treatment is indicated?

D. Critical-thinking concepts:

1. How does entering visual acuity impact the provider's decision-making in this case? Would it be different if vision were worse than 20/20?
2. What inferences are made in the determination of the diagnosis?
3. If any one particular test performed during the visit was not completed, would the provider have been able to make the diagnosis?
4. What are the potential implications involving the management of this patient?
5. What if symptoms worsen or do not improve?
6. How would management have been different if an ophthalmologist had not been as easily accessible to the patient?
7. What are some effective strategies to reassure patients with self-resolving conditions?

Teaching instructions and assessment methodology
The purpose of this case report is to help clinicians review the clinical features and course of MEWDS as well as develop strategies for reassuring patients at the end of a clinical encounter. Optometry students can be guided through a discussion in a classroom or clinical setting. They should be presented with case details in a stepwise fashion (i.e., case history, dilated fundus examination, automated threshold visual fields, OCT) to think critically through the clinical presentation, devise differentials and arrive at a diagnosis. The key aspects of patient education can be discussed, including delivery of the diagnosis, management options and ocular prognosis.

The keys to diagnosis in this case were a thorough case history including systemic history and review of systems, a comprehensive dilated ocular evaluation and critical-thinking skills to incorporate and interpret additional test findings (HVF and OCT) as part of the visit. It is important that clinicians make an accurate MEWDS diagnosis and rule out other sight-threatening retinal pathology that would require treatment. MEWDS management is generally observation, and the condition has a good prognosis. In contrast, other white dot syndromes require invasive treatment and have worse prognoses.

Discussion

White dot syndromes

MEWDS was first reported in 1984, described as a transient chorioretinopathy often preceded by a viral-like illness. It is noted to be a clinical entity distinct from other inflammatory white dot syndromes such as acute macular neuroretinopathy, acute posterior multifocal placoid pigment epitheliopathy (APMPPE), acute retinal pigment epitheliitis, birdshot choroidopathy,

multifocal choroiditis (MFC) with panuveitis, and punctate inner choroidopathy.[1-4]

Table 2. *Click to enlarge*

This group of inflammatory disorders produces discrete, yellow/white retinal lesions in young adults, which can be differentiated by history, appearance, laterality and FA **(Table 2)**. MEWDS commonly presents with macular granularity and "wreath-like" hyperfluorescence on FA. MEWDS generally affects healthy, myopic women (4:1 compared to males) in their third or fourth decade, but patients in their 50s have been reported.[4] The annual incidence is 0.22 per 100,000.[5] There are no known genetic or racial predilections. A viral prodrome has been reported in more than 50% of cases.[3-6]

Etiology

The exact pathogenesis of MEWDS is unknown, but it is thought to be caused by an underlying autoimmune (non-infectious) mechanism. Suggested explanations include viral agents entering retinal receptor cells at the edge of the optic nerve and ora serrata, triggering an autoimmune response.[6] An association with environmental triggers and human leukocyte antigen (HLA)-B51 has been reported.[4-6] Cases have also presented after vaccinations for human papillomavirus, hepatitis A, and hepatitis B.[7-10] One theory holds that choriocapillaris hypoperfusion or non-perfusion results in ischemic damage to the outer retina and RPE due to a vaso-occlusive process involving small vessels, whereas other white dot syndromes such as APMPPE and MFC involve larger blood vessels.[11] Few reports provide an explanation for differences between retinal spots and dots. A recent report suggests a shallow infiltration of inflammatory cells within the inner choroid or outside the choriocapillaris, beneath the RPE, is what causes smaller retinal dots in MEWDS.[2]

Clinical features

Patients with MEWDS may complain of sudden, unilateral changes in vision including decreased acuity, visual field defects consistent with enlarged blind spots or scotomas, photopsias or color vision changes.[1-6] Visual acuity may vary, ranging from 20/20 to 20/400 in some cases.

Clinical manifestations include small, gray-white retinal dots and spots ranging in size from 100-200 µm. Some reports have described differences between the retinal dots and spots based on their location; dots appear more anteriorly at the level of the outer retina and RPE, and spots appear deeper at the RPE and inner choroid.[2] Dots may present greater in number around the optic nerve and nasal retina.[6] The macular region may also have a fine, granular appearance, which has been reported to be pathognomonic for MEWDS.[4] A relative afferent pupillary defect (RAPD) may be present, as well as mild optic nerve inflammation, mild vitreous cells and mild anterior chamber reaction.

Retinal lesions are usually transient and tend to resolve within 3-10 weeks, with larger spots resolving quicker than smaller dots. After the acute clinical phase and resolution of retinal lesions, minimally evident macular and paramacular granularity may persist.[3-6]

Differential diagnosis

Clinicians must be diligent in ruling out potentially ominous causes of a patient's perceived visual field defect, whether it be of ocular or neurological origin. Upon chief complaint of "gray spot" associated with blur and loss of vision, a broad range of differentials could be considered including ocular inflammation, optic neuropathy, macular disease and retinal detachment.[12] A condition commonly encountered in clinic in young, healthy patients is central serous retinopathy (CSR). However, this patient did not fit the classic demographics of being a myopic male under recent stress or with Type A personality. Other retinal conditions that may cause a patient to present with a scotoma include MEWDS and central pigment epithelial detachment.

Given this patient's history of migraine with aura, it is reasonable to consider an atypical ocular migraine as the cause of the symptoms, but this should be a diagnosis of exclusion, which was certainly ruled out with clinical exam. Classic symptoms of ocular migraine include flashing or shimmering lights, blind spots, floating lines and zig-zag patterns, and symptoms may occur without headache. When questioned, the patient denied headache but reported recently having the flu, which was confirmed by her primary care physician and managed with over-the-counter medications.

MEWDS is diagnosed by clinical observation and can be confirmed with electrophysical and angiographic testing **(Table 3)**. Careful case history, clinical appearance and ancillary testing help to differentiate MEWDS from other white dot syndromes.[3-6] Testing may include:

TABLE 3
MEWDS Diagnostic Testing

	OCT	ICGA	FAF	FA
Early phase	Disrupted IS/OS junction band or dome-shaped hyper-reflective lesions subretinally; increased reflectivity of the choroidal space	hypocyanescent dots, usually greater in number than on FA or on clinical exam	multiple round dots/ spots with increased autofluorescence, pinpoint areas of decreased autofluorescence around disc and macula (brown lesions visible on exam)	"wreath-like" punctate hyperfluorescence of dots and spots some dots with hypofluorescence or mixed appearance
Late phase	N/A	hypocyanescent dots; hyperfluorescent dots later (20 minutes after injection)	lesions may disappear, lessen in number or become more hypoautofluorescent in appearance (halo or throughout lesion)	staining of lesions and optic nerve
Persistent findings	findings gradually resolve; ONL thinning may persist and permanent retinal atrophy is possible	findings gradually resolve	abnormalities may persist for months after resolution of condition and ICGA findings	findings may persist, indicating retinal damage

FA = fluorescein angiography
FAF = fundus autofluorescence
ICGA = indocyanine green angiography
IS/OS = inner segment/outer segment
OCT = optical coherence tomography
ONL = outer nuclear layer

Table 3. *Click to enlarge*

- OCT: OCT may reveal disruption to the hyper-reflective band attributed to the photoreceptor inner segment/outer segment junction or dome-shaped subretinal hyper-reflective lesions. Increased reflectivity of the choroidal space has also been reported.[6] OCT findings gradually resolve with resolution of the disease; however, outer nuclear layer thinning has been apparent in cases of recurrent disease, suggesting that repeated episodes may result in permanent retinal atrophy.[6]
- FA: FA usually demonstrates early punctate hyperfluorescence corresponding to retinal dots and spots, with late staining of the lesions and optic nerve. Dots appear during the choroidal-filling and retinal artery perfusion phases, often in multiple clusters in a "wreath-like" pattern near the macula. Depending on duration of symptoms at presentation, variances in equipment and imaging modality, and severity of the condition, FA appearance may also include hypofluorescent lesions or even appear normal. Resolution of FA findings correlate to resolution of retinal lesions.[6]
- Indocyanine green angiography (ICGA): Hypofluorescence is evident in early and late phases. Multiple hyperfluorescent dots may appear in the late phase 20 minutes after injection, characteristically more numerous and less "wreath-like" than noted on clinical examination and FA.[3-6]
- Fundus autofluorescence (FAF): In the acute phase, retinal dots and spots show up as increased areas of autofluorescence, and pinpoint areas of decreased autofluorescence around the disc and macula may be seen. As MEWDS resolves, hyperfluorescent lesions disappear and hyperfluorescent spots may lessen in number, resolve, become smaller in size, or have a more hypoautofluorecent appearance (either a halo or throughout the lesion). FAF abnormalities may persist for months after diagnosis and after resolution of FA-ICGA abnormalities.
- Electrophysiologic testing: electro-oculogram (EOG) demonstrates reduced light-dark ratios, and electroretinogram (ERG) shows reduced a-waves and early receptor potentials.
- Visual field testing: Automated visual field testing may reveal an enlarged blind spot or scotomas (central, paracentral, temporal or scattered). Although not diagnostic, automated visual field testing may be useful in ruling out possible neurological causes for visual field reductions and ruling in retinal disease (especially with central 10-2 testing). Documentation of the visual field defect may be useful for patient education as well as monitoring disease course and symptoms.
- Fundus photography: While also not diagnostic, fundus photography may be useful in documenting the current status of the retina, which may change based on duration of disease. In early stages, photodocumentation of yellow-white retinal spots in the posterior pole and midperiphery is common. Lesions appear at the level of the outer retina, RPE and inner choroid. Foveal granularity described as small white or orange pinpoint specks may be pathognomonic for MEWDS. As the clinical course progresses, retinal dots and spots may fade or appear more reddish/brown before resolving completely.
- There have been reports of MEWDS cases without dots or spots on clinical examination that were identified with both FA and ICGA as well as ICGA alone.[2] There are few reports of cases without retinal spots and macular granularity alone, but this may represent differing timing in the clinical course. This case is one example of a MEWDS presentation with macular granularity as the only clinical sign on dilated examination, consistent with changes on OCT and HVF testing but not identified on FA.

Management

The prognosis for MEWDS is generally good with spontaneous resolution of retinal lesions within weeks to months (3-10 weeks).[3-4] Symptoms generally improve shortly after; however, OCT, angiographic and visual field abnormalities may take longer to resolve. In some cases, visual field defects and photopsias may persist. Recurrence is rare, but is estimated to occur in approximately 10% of cases.[6] An Amsler grid can be given to patients to monitor their vision at home. Treatment is not usually necessary; however, recurrent cases have been treated with cyclosporine, and rare incidents of choroidal

neovascularization have been treated with intravitreal ranibizumab.[4]

Critical-thinking concepts

Because the degree of visual acuity loss may vary in cases of MEWDS, ranging from 20/20 to 20/400, it should not be used as an indicator of disease. In this case, the patient's UCDVA was 20/20 in each eye and thus did not lead to high suspicion of macular disease at the start of the examination. For this reason, color vision and Amsler grid testing were not performed at the initial visit. However, because color vision changes may be a presenting symptom, it may be helpful to perform color vision testing to document any defects as well as resolution of symptoms throughout the clinical course of MEWDS. Anterior segment slit lamp examination revealed no signs of corneal disease or anterior uveitis. Dilated fundus evaluation showed flat optic nerve heads, well-perfused with distinct margins in each eye. Thus, optic neuritis, optic atrophy and optic neuropathy were ruled out. Additionally, there were no signs of vitritis, serous detachments, pigment epithelial detachments or retinal breaks, thus CSR and retinal detachment were ruled out. The only remarkable retinal finding was a fine macular granular change outside the fovea of the left eye; there were no classic white retinal spots or dots. It is possible that retinal spots and lesions were present prior to the patient arriving for evaluation and had already self-resolved, revealing only granularity correlating to abnormal HVF and OCT test results.

This patient fits the classic profile of patients diagnosed with MEWDS. However, without a thorough case history revealing recent-onset flu and without a stepwise approach to investigating symptoms with careful dilated examination and the addition of HVF and OCT testing, the diagnosis may not have been made. In this case, the clinical picture did not include classic white spots/dots. Clinical pearls for students are to have a high level of suspicion when examination does not reveal obvious pathology and to order additional testing when clinical findings do not fully correlate with patients' symptoms. In this case, HVF testing was performed to rule out any neurological etiology for the patient's visual field complaints as undilated examination revealed no obvious pathology. As it turned out, the central visual field defect suggested macular pathology, and macular OCT was ordered while the patient's pupils were dilating. Photoreceptor integrity line abnormalities on OCT correlated with fundus examination, HVF test findings and the patient's complaint.

TABLE 4
A Six-Step Strategy for Patient Reassurance[15]

Collect Data
• Empathize and show concern by collecting history; question, listen, clarify • Develop rapport; collect information and examine the patient
Give Accurate Information
• Inform the patient that a serious illness is not present, and condition may be temporary • Consider using the phrase "at the current time" • Sometimes labeling the patient with a diagnosis may be helpful as a point of reference for the patient to better understand the condition. However, if this label creates more worry and anxiety regarding symptoms, using nonspecific descriptions or terminology may be preferred.
Suggest a Timeline
• Give patient probable timeline for resolution of symptoms and condition
Return to Normal Activities
• Explain to patient he/she can return to work and recreational activities without fear of aggravating the condition or worsening symptoms
Consider Non-Specific Treatment (if appropriate)
• In some situations when organic disease is not present, recommending short-term medications and lifestyle changes such as altering diet and exercising may have a placebo effect that helps improve patient's symptoms
Follow-Up with Patient
• Scheduling follow-ups with patients may give them a sense of security knowing that the provider has acknowledged and has concern about their complaint • Scheduling a follow-up decreases the likelihood of patient seeking care from other providers, and ultimately increasing healthcare costs

Table 4. *Click to enlarge*

Although fundus photography may be useful in documenting the clinical course of MEWDS, and can be used as a visual aid during patient education, it was not performed at the initial visit due to minimal retinal changes observed on clinical examination as well as scheduling and billing/insurance constraints. Other tests that could have been ordered were FAF, FA, ICGA, and ERG/EOG; however, they were not available at the practice. The patient was referred to a nearby ophthalmology practice where OCT was repeated and FA was performed, ruling out underlying vasculitis or inflammation. Although FA often shows "wreath-like" hyperfluorescent dots corresponding to retinal dots observable in the acute phase of MEWDS, this patient did not present with retinal dots and thus there was no hyperfluorescence on FA. It is possible that retinal spots had already appeared and resolved in the 10 days prior to FA being performed. However, there have also been cases of MEWDS that present without retinal spots; therefore, FA should not be solely relied upon for making a MEWDS diagnosis.

Often, when health conditions are self-limiting or without clear cause, clinicians may attempt to reassure patients to decrease their concern or worry and improve outcomes.[13] Clinicians may use several strategies including developing rapport with the patient, empathizing with him/her and providing accurate information and explanations about the condition.[14] A six-step strategy for patient reassurance has been described **(Table 4)**.[15]

Though there are many theoretical models of patient reassurance, the effectiveness of each approach has not been extensively studied and there are no standardized methods of delivering reassurance.[13] Preliminary clinical trial evidence does suggest that a more cognitive approach (information, education) may be more effective than an affective approach (rapport building, empathy) in the long run. However, a mixture is commonly employed.[13] Different patients may require different strategies for reassurance, thus a patient-centered approach should be considered in each case.[13-15]

Conclusions

This case serves as a reminder that young, seemingly healthy patients without chronic systemic disease can have less commonly encountered retinal pathology. This patient experienced acute-onset viral symptoms followed by changes in vision caused by MEWDS. This case report is intended to educate eyecare providers on the clinical course and management of MEWDS, highlighting the importance of thorough case history, careful ophthalmic examination, and critical thinking in analyzing information throughout the examination. While MEWDS is uncommon and generally has a good prognosis, it is important that clinicians are able to accurately diagnose and educate patients on its course.

References

1. Jampol LM, Sieving PA, Pugh D, Fishman GA, Gilbert H. Multiple evanescent white dot syndrome. I. Clinical findings. Arch Ophthalmol. 1984 May;102(5):671-4.
2. Gross NE, Yannuzzi LA, Freund KB, Spaide RF, Amato GP, Sigal R. Multiple evanescent white dot syndrome. Arch Ophthalmol. 2006 Apr;124(4):493-500.
3. Friedman N, Kaiser P, Pineda R. The Massachusetts Eye and Ear Infirmary illustrated manual of ophthalmology. 3rd ed. Saunders Elsevier; 2009. 634 p.
4. Crawford CM, Igboeli O. A review of the inflammatory chorioretinopathies: the white dot syndromes. ISRN Inflamm. 2013 Oct 31;2013:783190.
5. Abu-Yaghi NE, Hartono SP, Hodge DO, Pulido JS, Bakri SJ. White dot syndromes: a 20-year study of incidence, clinical features, and outcomes. Ocul Immunol Inflamm. 2011 Dec;19(6):426-30.
6. dell'Omo R, Pavesio CE. Multiple evanescent white dot syndrome (MEWDS). Int Ophthalmol Clin. 2012;52(4):221-8.
7. Fine HF, Spaide RF, Ryan EH, Matsumoto Y, Yannuzzi LA. Acute zonal occult outer retinopathy in patients with multiple evanescent white dot syndrome. Arch Ophthalmol. 2009 Jan;127(1):66-70.
8. Stangos A, Zaninetti M, Petropoulos I, Baglivo E, Pournaras C. Multiple evanescent white dot syndrome following simultaneous hepatitis-A and yellow fever vaccination. Ocul Immunol Inflamm. 2006 Oct;14(5):301-4.
9. Baglivo E, Safran AB, Borruat FX. Multiple evanescent white dot syndrome after hepatitis B vaccine. Am J Ophthalmol. 1996 Sep;122(3):431-2.
10. GlaxoSmithKline Vaccine HPV-007 Study Group; Romanowski B, de Borba PC, Naud PS, et al. Sustained efficacy and immunogenicity of the human papillomavirus (HPV)-16/18 AS04-adjuvanted vaccine: analysis of a randomised placebo-controlled trial up to 6.4 years. Lancet. 2009 Dec 12;374(9706):1975-85.
11. Lages V, Mantovani A, Papadia M, Herbort C. MEWDS is a true primary choriocapillaritis and basic mechanisms do not seem to differ from other choriocapillaritis entities. J Curr Ophthalmol. 2018 Nov 15;30(4):281-286.
12. Bagheri N, Wajda B. The Wills Eye Manual: Office and Emergency Room Diagnosis and Treatment of Eye Disease. 7th ed. Lippincott; 1994. 10 p.
13. Pincus T, Holt N, Vogel S, et al. Cognitive and affective reassurance and patient outcomes in primary care: A systematic review. Pain. 2013 Nov;154(11):2407-16.
14. Traeger AC, O'Hagan ET, Cashin A, McAuley JH. Reassurance for patients with non-specific conditions – a user's guide. Braz J Phys Ther. 2017 Jan-Feb;21(1):1-6.
15. Kathol RG. Reassurance therapy: what to say to symptomatic patients with benign or non-existent medical disease. Int J Psychiat Med. 1997;27(2):173-80.

When a Red Eye is More than Meets the Eye: a Teaching Case Report on the Public Health Role of the Eyecare Provider

Julia Appel, OD, FAAO | Optometric Education: Volume 45 Number 3 (Summer 2020)

Background

Patients presenting for care of "red eye" can be challenging due to the numerous etiologies and potential systemic associations. A systematic evaluation of presenting signs and symptoms with development of an inclusive differential diagnosis is required, but is complicated when unknown concurrent systemic infection is present. Collaboration with the patient's primary care physician (PCP) and a working knowledge of the epidemiologic contributing factors provide a deeper understanding in this process, and add certainty to diagnostic expertise when more rare conditions present. The following clinical case endeavors to teach optometry students two critical aspects of their role as clinicians: the importance of basic knowledge about significant but relatively rare differential diagnoses of a common complaint, and that optimal care and improved outcomes result with application of epidemiologic principles. True proficiency in providing optimal care encompasses more than the understanding of diagnosis and management, and the earlier epidemiological principles are introduced, the better.

This teaching case report is for use with latter second-year optometry students (and beyond) who understand the differential diagnosis and treatment options for conjunctivitis/uveitis and have a basic understanding of epidemiological concepts.

Case Description

A 38-year-old Caucasian male presented to the eye clinic with a chief complaint of an irritated right eye of two-day duration. The patient complained of burning, tearing, mild photosensitivity and mild foreign body sensation of the right eye. There was no complaint of significant blur, pain, flashes, floaters, diplopia, headache, dryness, recent upper respiratory infection or allergy. The patient had seen his PCP one day prior when symptoms began. The PCP ruled out a corneal abrasion, recommended artificial tears, and referred the patient to the eye clinic for further evaluation if symptoms persisted or worsened.

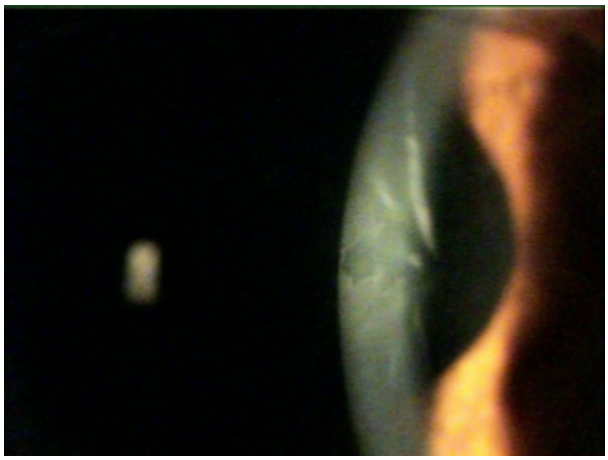


Figure 1. *Slit lamp image captured at the patient's initial visit.* *Click to enlarge*

Initial visit

Mild facial swelling near the jaw observed at the eye clinic visit was due to overnight teeth grinding according to the patient. All other systemic and medical history was negative. Best-corrected visual acuity (BCVA) was 20/25-OD and 20/20 OS. Pupillary reactions and extraocular motilities were normal.

Slit lamp biomicroscopy of the patient's left eye was unremarkable. Slit lamp findings for the right eye **(Figure 1)** were:

- Mild diffuse hyperemia with limbal flush
- Trace anterior chamber reaction (cells and flare) with fine keratic precipitates diffusely
- Moderate, diffuse corneal edema with endothelial folds
- Mild central punctate staining
- Goldmann applanation tonometry: 24 mmHg OD, 14mmHg OS at 11:50 a.m.
- Palpation of preauricular lymph nodes: no discomfort and no significant elevation on the right side relative to the left
- Gonioscopy was inconclusive OD because of poor views due to edema; angles were open 360° OS
- Pachymetry not performed at this visit

- Fundus findings were unremarkable OD, OS and non-contributory

A working diagnosis of anterior uveitis with corneal edema and increased intraocular pressure (IOP) OD without known etiology was determined. **Table 1** lists initial treatment. Initiation of intraocular pressure lowering drops would commence if intraocular pressure remained elevated at follow up visit.

One-day follow-up visit

The next day the patient reported complete adherence to the prescribed topical medication regimen, improved ocular symptoms, and mild worsening with dry mouth and testicular pain. He reported a generalized feeling of being unwell and was to return to his PCP that afternoon. See **Table 1** for treatment changes. Additional findings:

- Continued mild injection OD, improving
- Moderate/severe corneal edema; pachymetry: 760 µm OD, 569 µm OS
- Improving but still elevated IOP (18 mmHg OD, 14 mmHg OS)

Further investigation of the new systemic symptoms, patient physical and ocular presentation revealed a likely diagnosis of mumps-related endotheliitis with associated trabeculitis. The provisional diagnosis of endotheliitis associated with epidemic parotidis was discussed with the PCP by phone. The physician's evaluation of the patient and subsequent immunoglobulin M titers confirmed the diagnosis. Despite vaccination as a child, the patient contracted mumps from an unknown source, which raises the questions "How can this be and how does it influence our future evaluation of vaccinated individuals?"

TABLE 1
Summary of Patient Visits

	Initial	1 day	1 week	2 weeks	1 month	2 months
Best-corrected visual acuity	20/25- OD 20/20 OS	20/30 OD 20/20 OS	20/50-2 OD 20/20 OS	20/25 OD 20/20 OS	20/20+2 OD 20/20+ OS	20/20 OD 20/20 OS
Anterior segment (all findings are OD)	moderate edema with few endothelial folds; trace cells, fine diffuse keratic precipitates; 2+ diffuse injection	moderate to severe edema with many endothelial folds diffusely, no anterior chamber reaction; 1+ injection	severe edema with endothelial folds of central cornea, epithelial edema	mild diffuse edema, few endothelial folds and resolution epithelial edema	few endothelial folds with trace central endothelial opacity	clear, complete resolution of all anterior segment anomalies
Intraocular pressure	24 mmHg OD 14 mmHg OS	18 mmHg OD 14 mmHg OS	18 mmHg OD 13 mmHg OS	11 mmHg OD 12 mmHg OS	13 mmHg OD 14 mmHg OS	13 mmHg OD 14 mmHg OS
Pachymetry		760 µm OD 569 µm OS	846 µm OD	840 µm OD	615 µm OD	580 µm OD 565 µm OS
Treatment (OD)	prednisolone acetate 1% q1h; homatropine 5% qid	prednisolone acetate 1% qid; homatropine 5% qd	prednisolone acetate 1% q2h; discontinue cycloplegic; add Muro 128 5% qid	prednisolone acetate 1% qid; discontinue Muro 128	all drops discontinued by patient; add artificial tears qid	

q1h = once every hour
q2h = once every two hours
qid = 4 times per day

Table 1. *Click to enlarge*

Education Guidelines

Key concepts

1. Differential diagnosis of endotheliitis systemic etiologies
2. Application of epidemiologic principles and collaborative care practice in providing optimal health care
3. Vaccination against preventable infectious disease

Learning objectives (LO)

Utilization of this case to educate separately on ocular/systemic disease or epidemiological emphasis is possible, but use of this report in its entirety will enhance the student's ability to:

1. Participate collaboratively in the diagnosis of epidemic parotidis with an understanding of the ophthalmic and systemic ramifications
2. Independently diagnose and treat the secondary ocular manifestation of endotheliitis with an understanding of the underlying pathophysiology
3. Utilize and apply the epidemiological concepts determining risk of infection with this and other preventable viral etiologies
4. Gain working knowledge and use of epidemiological resources to aid in the care of patients presenting with infectious disease

Education activities/case discussion

Presenting the case using a grand rounds approach can help students hone their skills as they answer questions in determining additional testing and next steps for care in the evaluation and management of problem-focused exams.

- Poll Everywhere or Turning Point allow for real-time assessment of student participation, or a quiz preceding and after review and discussion of the case can assess understanding of relevant clinical care concepts. The quiz, geared toward the level of learner, can emphasize both epidemiology and ocular/systemic manifestations utilizing content provided in the discussion. (LO 1-4)

Deep learning/critical thinking opportunities exist as students break into smaller groups to independently explore and present back to the larger group or post on the course online learning management system. The discussion section and resources listed provide a starting point for these active learning exercises:

- Develop a problem representation grid (illness script) of the differential diagnosis of conjunctivitis including endotheliitis. Independent development and completion by the students or a grid provided with some data points missing are options. (LO 1, 2)
- Discuss the role of anterior chamber-associated immune deviation (ACAID) in this condition and its effect on management of ocular inflammation. (LO 2)
- Develop a basic protocol for patient medical and visual conditions that require interprofessional collaboration (include examples of which conditions need outreach and why, modes of contacting the PCP and what information should be provided. Knowledge of clinical medicine concepts is helpful or working with the instructor as facilitator are options. (LO 1)
- Access and use the Morbidity and Mortality Weekly Report (MMWR) database to research the prevalence of a viral illness in the United States and its ophthalmic manifestations (herpes zoster, Zika, chikungunya, West Nile, yellow fever, Rift Valley fever, etc.) (LO 3, 4)
- Investigate the autism vaccination controversy and debate it using two peer-reviewed resources on either side. (LO 3, 4)
- Discuss the concepts of herd (community) immunity and long-term seroprevalence/vaccination efficacy for measles, mumps and rubella given recent national outbreaks of measles and mumps. (LO 1, 3, 4)

Assessment of the above learning activities depend on the course type and facilitator goals. While rigorous grading rubrics for the activities for summative evaluations are possible, these activities lend themselves to seminar and adjunctive content and are better assessed in a formative manner for clarity and content. Access to all group activity reports or best examples of each activity posted on the learning management system for student review will maximize learning opportunities to meet all learning objectives.

Literature review

Mumps (epidemic parotidis)

Epidemic parotidis[1] is a contagious acute paramyxovirus infection of the salivary glands presenting as swelling of one or both parotid glands and flu-like symptoms. Hence, this patient's swelling near the jaw was not associated with teeth grinding, and his dry mouth on day two was not due to use of a cycloplegic agent but rather the parotid gland dysfunction. The incubation period of epidemic parotidis is 12-25 days and glandular involvement occurs 16-18 days after exposure. While the parotidis and viral illness are self-limiting and usually resolve within 10 days, significant systemic complications, including pelvic inflammation in males (orchitis) and females (oophoritis), can occur, especially after puberty. The patient's complaint of testicular pain on day two was associated with orchitis, but this presentation rarely results in sterility. Neurosensory hearing loss can occur but usually returns to normal post-infection.

Before the introduction of single-dose vaccination with live attenuated virus in 1967, mumps accounted for a significant percent of cases of aseptic meningitis in the United States. Other serious systemic complications such as pancreatitis were also reported, although death from infection was exceedingly rare. Once the two-dose vaccination regimen came into common use, significant drops were seen in all systemic complications and no deaths were reported.

Endotheliitis typical presentation

The most common ophthalmic manifestation of epidemic parotidis is endotheliitis (sometimes associated with trabeculitis as in this presentation). The condition typically presents as:[2]

- mild to moderate anterior chamber reaction
- unilateral involvement

- fine keratic precipitates that can be confused with endothelial pigment
- sectoral or diffuse corneal edema with endothelial folds
- microcystic edema resulting from aggressive stromal edema
- elevated IOP (if trabeculitis is also present)

Pathology

Corneal endotheliitis is a clinical diagnosis based on specific characteristics **(Table 2)**. The pathology of endotheliitis is endothelial viral proliferation resulting in an inflammatory response.[2] There is subsequent failure of the endothelial cell pump leading to edema and loss of transparency that can lead to long-term endothelial damage.[2] Subsequent inflammation of the trabecular meshwork is possible and leads to reduction in aqueous outflow and increased IOP.

It was not until 1985 that researchers identified the viral etiology of this presentation by isolating herpes simplex virus (HSV) in the aqueous humor and detecting HSV-1 antigen in the anterior chamber of affected eyes.[3] Some evidence indicates that HSV originates from the trabeculum as patients with endotheliitis have shown HSV on excised trabecular tissue and this is consistent with the peripheral presentation of HSV-related endotheliitis.[4] Later, identification of other contributing viral etiologies, including the rarely encountered epidemic parotidis-related endotheliitis, followed. [5]

The role of ACAID results in a relatively reduced inflammatory response despite the direct infection of ocular tissue due to the suppression of a delayed hypersensitivity reaction.[6] However, the reduced cell-mediated immunity to viral particles shed into the anterior chamber allows for viral proliferation in the corneal endothelium leading to the presentation of endotheliitis.[2] The pathogenesis of mumps-related endotheliitis varies from this and may be associated with the level of viremia, but the rarity of the condition makes further research difficult.[5]

TABLE 2
Endotheliitis Treatment with Systemic Differential
Utilizing Information from Krachmer, Suzuki [24]

Corneal endotheliitis presentation	Systemic etiology	Presentation	Treatment
Linear	HSV, CMV	unilateral, peripheral and sectoral edema with line of keratic precipitates at sector edge (coin shaped lesions-CMV), minimal anterior chamber reaction, progressive loss of endothelial cells	aggressive treatment with topical and oral antiviral agents (based on specific viral etiology) and corticosteroids
Diffuse	epidemic parotidis	rare, diffuse corneal edema, fine keratic precipitates, spontaneous resolution occurs within 2 weeks, endothelial cell loss can occur	topical corticosteroids if mumps-related with trabeculitis present, antiviral therapy considered if mumps unlikely
Disciform	HSV, VZV	most common, focal round edema, multiple keratic precipitates, mild to moderate anterior chamber reaction, endothelial cell loss not common	most likely to respond to topical corticosteroids, association with latent virus from prior infectious keratitis

HSV = herpes simplex virus
CMV = cytomegalovirus
VZV = varicella zoster virus

Table 2. *Click to enlarge*

Endotheliitis is not completely benign as endothelial cell loss can occur. As this cell layer does not regenerate, future pathology or necessary procedures such as cataract extraction may result in further corneal decompensation and vision loss. Systemic treatment of recalcitrant HSV-related endotheliitis may be necessary (oral acyclovir or valacyclovir) along with topical corticosteroids. However, cytomegalovirus (CMV)-related endotheliitis often does not respond to topical corticosteroids and requires aggressive systemic management (IV ganciclovir) to protect vision.[8] Consultation with the patient's PCP when confronted with suspicions of systemic herpetic disease is highly recommended for best outcomes. In addition to topical corticosteroids, topical ganciclovir ophthalmic gel 0.15% five times daily supplements treatment of disciform and linear endotheliitis associated with HSV and varicella zoster virus but may show limited effectivity for CMV etiology.[8]

The Centers for Disease Control and Prevention (CDC) is a federal agency under the U.S. Department of Health and Human Services tasked with monitoring and prevention of disease. The agency's mandate is to protect the nation's health, and as part of its mission it "conducts critical science and provides health information that protects our nation against expensive and dangerous health threats, and responds when these arise."[9] Promoting vaccination against preventable infectious disease is a part of this mandate. Current CDC recommendations for infectious childhood diseases include vaccination against varicella, rubella, measles, mumps, polio, and diphtheria. The agency cites studies showing the safety of these recommendations as well as their impact on morbidity and mortality.[1] Patients and their parents may ask healthcare providers for their opinions on vaccination, making a working knowledge of the subject important. Resources for practitioners and the public are available on the CDC website.

Vaccination is the most effective way to prevent the spread of epidemic parotidis. The measles, mumps rubella (MMR) or measles, mumps, rubella, varicella (MMRV) vaccine protocols call for two doses. The first is administered at age 12-15 months; a booster is administered at age 4-6 years.[10]

Other resources such as the CDC publication of the MMWR can provide current, evidence-based public health information as well as recommendations and their impact on public health. The MMWR provides real-time information on outbreaks occurring nationally.[11]

Those most at risk for mumps

Individuals most at risk for contracting epidemic parotidis include:[1]

- those who have not been vaccinated, including infants too young to be vaccinated
- healthcare workers in clinic/hospital settings
- those living in close quarters, such as college students or members of traditional communities
- persons traveling overseas to countries that do not require mumps vaccination
- vaccinated members of a certain U.S. population subset

Outbreaks of mumps have occurred in adult populations and in communities of all ages in the recent past. If healthcare providers are not informed, they may miss important diagnoses and patient education opportunities. The public health impact of optometrists' contributions to care is significant as a solid understanding of epidemiologic principles is critical for evidence-based practice and can inform or guide care protocols and referrals for best patient outcomes. Treatment of a presenting condition such as endotheliitis is only the beginning. A deeper understanding of those at risk for underlying, causative systemic disease will provide for more timely identification and diagnosis with the potential to reduce the spread of infection.

MMR vaccine efficacy

The MMR vaccine is highly successful in providing long-term protection against measles and rubella but is not as effective in maintaining immunity to mumps over time. Mumps seropositivity shows less persistence over time with one dose resulting in 78% immunity (49-92%) and two doses resulting in 88% immunity (66-95%).[1] While herd or community immunity to prevent spread of disease is known to be 92%, the low persistence of mumps seropositivity does not result in pervasive epidemic rates of infection. One study of a small community showed only 74% of residents with measurable immunity 15 years after a second dose of MMR vaccine, yet no members of the community developed epidemic parotidis.[12] This is due to limited rates of exposure to the disease. Therefore, high vaccination rates paired with lack of exposure result in eradication of acute infection, but to be truly effective in this regard, both are required.

Why did this patient get mumps?

A survey of epidemiological resources is helpful in learning why the patient in this case contracted mumps. CDC evaluators used data from the 1999-2004 National Health and Nutrition Examination Survey (NHANES) to assess mumps antibody seroprevalence in the U.S. population.[13] They found 90% of those surveyed were immune (borderline to prevent disease spread). However, some subsets showed lower rates of immunity. Specifically, those born between 1967 and 1976 showed only 85.7% seropositivity. These single-dose recipients were too old to have been exposed naturally as children and too young to have received the more persistent two-dose regimen. Therefore, they were more likely to be at risk of developing infection when exposed.[13] Based on his age, this patient fell into that demographic.

Unfortunately, a reduction in vaccination rates has resulted in outbreaks in the United States in recent years. In 1998, a paper by Wakefield et al. raised concerns of autism risk in those receiving the MMR vaccine. This led to parental reluctance to immunize children against multiple infectious diseases.[14] Ultimately, significant decreases in vaccination rates resulted in some communities. Although this theory has been debunked through retrospective and prospective research, and the original paper was found to be fraudulent and retracted, the safety concern continues to affect U.S. vaccination rates. Literature review shows that parents opting out of vaccinating their children not only puts the unvaccinated individual at risk for preventable disease but also increases the likelihood of spreading disease throughout the greater community.[15]

Conclusion

A seemingly simple complaint of red eye can signal a significant threat to a patient's health and well-being. The ability to recognize important features that indicate potentially harmful systemic etiology, such as rash, swollen glands, associated symptoms or unique ocular findings, makes optometrists effective contributors to the overall care patients receive. By collaborating with PCPs, optometrists can implement timely and appropriate ocular and systemic treatment. Recognizing a rare presentation such as epidemic parotidis-related endotheliitis is important and may become increasingly so as mumps outbreaks become more prevalent due to a reduction in vaccination rates. Understanding the relevant epidemiologic principles and being familiar with available resources enable a quick response when new infectious diseases are present in local communities and abroad.

References

1. Manual for the surveillance of vaccine-preventable diseases. Centers for Disease Control and Prevention, Atlanta, GA, updated 2017. Clemmons N, Hickman C, Lee A, Marin M, Patel M. Chapter 9: Mumps [accessed 1/10/19]. Available from: https://www.cdc.gov/vaccines/pubs/surv-manual/chpt09-mumps.html

2. Suzuki T, Ohashi Y. Corneal endotheliitis. Semin Ophthalmol. Jul-Aug 2008;23(4):235-40.
3. Robin JB, Steigner JB, Kaufman HE. Progressive herpetic corneal endotheliitis. Am J Ophthalmol. 1985 Aug 15;100(2):336-7.
4. Amano S, Oshika T, Kaji Y, Numaga J, Matsubara M, Araie M. Herpes simplex virus in the trabeculum of an eye with corneal endotheliitis, Am J Ophthalmol. 1999 Jun;127(6):721-2.
5. Singh K, Sodhi PK. Mumps-induced corneal endotheliitis. Cornea. 2004 May;23(4):400-2.
6. Hori J. Mechanisms of immune privilege in the anterior segment of the eye: what we learn from corneal transplantation. J Ocul Biol Dis Infor. 2008 Dec;1(2-4):94-100. doi: 10.1007/s12177-008-9010-6.
7. Krachmer KH, Mannis MJ, Holland EJ, editors. 3rd ed., Vol.1, Cornea. Mosby/Elsevier; 2011. Chapter 79: Herpes Simplex Keratitis; p.967-71.
8. Chee SP, Jap A. Treatment outcome and risk factors for visual loss in cytomegalovirus endotheliitis. Graefes Arch Clin Exp Ophthalmol. 2012 Mar;250(3):383-9.
9. About CDC 24-7, mission, role and pledge. Centers for Disease Control and Prevention, Atlanta, GA, page last reviewed 5/13/19 [accessed 1/10/19]. Available from: https://www.cdc.gov/about/organization/mission.htm
10. Vaccines & immunizations, parents (birth-18 years). Centers for Disease Control and Prevention, Atlanta, GA, updated 10/16/18 [accessed 2/13/19]. Available from: https://www.cdc.gov/vaccines/index.html
11. Morbidity and mortality weekly report. Centers for Disease Control and Prevention, Atlanta, GA [accessed 2/13/19]. Available from: https://www.cdc.gov/mmwr
12. Davidkin I, Jokinen S, Broman M, Leinikki P, Peltola H. Persistence of measles, mumps, and rubella antibodies in an MMR-vaccinated cohort: a 20-year follow-up. J Infect Dis. 2008 Apr 1;197(7):950-6.
13. Kutty PK, Kruszon-Moran DM, Dayan GH, et al. Seroprevalence of antibody to mumps virus in the US population, 1999-2004. J Infect Dis. 2010 Sep 1;202(5):667-74.
14. Wakefield AJ, Murch SH, Anthony A, et al. RETRACTED: Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children. Lancet. 1998 Feb 28;351(9103):637-41.
15. Omer SB, Salmon DA, Orenstein WA, DeHart MP, Halsey N. Vaccine refusal, mandatory immunization, and the risks of vaccine-preventable diseases. N Engl J Med. 2009 May 7;360(19):1981-8.

We've Had Our Challenges, and Creative Solutions, During the Pandemic

Aurora Denial, OD, FAAO, DipOE | Optometric Education: Volume 45 Number 3 (Summer 2020)

Aurora Denial, OD, FAAO, DipOE

While I was visiting my 5-year-old granddaughter recently, she proclaimed "I am mad at the coronavirus!" I couldn't help but feel the same. Our lives had changed on a dime in response to the virus. Our visit was in her backyard. We were six feet away, and I was unable to hug her or play. If she or my grandson came closer, immediately a mask went on. I had not held their new baby sister for months. Much had changed professionally as well. I was teaching my course remotely and attending at least two to three Zoom-In meetings per day.

Coronaviruses are a group of RNA viruses that can cause a range of respiratory illness in humans, from colds to potentially lethal illnesses such as severe acute respiratory syndrome (SARS), Middle East Respiratory Syndrome (MERS) and the novel coronavirus disease 2019 (COVID-19).[1] Coronaviruses are encased in a lipid "envelope" and have halo-like protrusions of protein. The word corona is Latin for halo, hence the name.[2]

In December 2019, a pneumonia of unknown cause presented in Wuhan, China. In January 2020, the previously unknown COVID-19 was identified as the cause.[3] The World Health Organization (WHO) classified the pneumonia outbreak as a pandemic on March 11.[4] As of mid-June, 8,400,320 cases had been confirmed worldwide and 2,173,804 cases had been confirmed in the United States.[5]

Perspective-changing Experiences

Although I had heard about the coronavirus in January, February and early March, I was not overly concerned nor could I have anticipated how everyday life would change. My institution, the New England College of Optometry (NECO), provided faculty with regular updates on potential plans for dealing with the outbreak.

My perspective changed drastically after two experiences. The first involved my youngest daughter, who works for a disaster relief organization, All Hands and Hearts. This organization rebuilds communities impacted by natural disasters. This is a hardy group of people, who go into the most challenging circumstances. My daughter was working on a project building schools in Sofala Province, Mozambique, which had been devastated by a cyclone in March 2019. Within 48 hours of the WHO announcement, All Hands and Hearts ceased all projects and made arrangements for employees to return to their home countries. My daughter's expedited return to the United States occurred despite the facts that she did not have her passport on base (it was at a government office) and two people on base came down with a pneumonia-like illness (later determined not to be COVID-related). The second experience arose when I decided to stock her refrigerator and cupboards in preparation for her arrival at home after five months away. I went to the local supermarket only to find completely empty shelves. Of course, there was no toilet paper, hand sanitizer or cleaning supplies, but pasta, flour and rice were also sold out, and the supplies of meats and produce were low. Seeing a large grocery store with so many empty shelves was chilling.

I now realized the enormity of the circumstances. Going forward, we would have new norms: social distancing, PPE, frequent hand-washing, etc. The news would be filled with new cases, death toll, lack of PPE, and the sacrifices of first-line workers. Optometric education, along with all education, would also be greatly altered.

Let's Share What We are Learning

NECO responded by moving all didactic classes online, cancelling or postponing labs, and altering clinical assignments. The college building was closed, and the clinics were open only for emergencies. All employees whose workloads were transferable to home began working remotely. I had never worked from home previously. Despite a long commute, I enjoyed coming into Boston daily and interacting with my colleagues. To my surprise, the transition to online teaching went smoothly. Technical support was readily available and course material was altered for online presentation. Initially, I was concerned about student engagement in my small group discussion courses. I was pleased to discover that students appeared even more engaged than they are in person. This may be at least partly attributed to my aggressively calling on all students to contribute. I try to

engage all students in person, but in every class there are shyer students who yield to more assertive and vocal peers. Lesson learned for me: aggressively utilize the roster for active participation by everyone. To facilitate clinical education, the college rolled out Electronic Learning Alternatives for Time not in Clinic (ELASTC).

All optometric institutions implemented similar alternative programs for teaching. The response of educators demonstrates flexibility, dedication and creativity. As much as I am still "mad at the coronavirus," it has provided freedom to try new teaching methods that otherwise may not have been utilized. In my opinion, student learning continued to be productive and sound. Going forward if possible, it may be sensible to evaluate qualitative and quantitative data on learning during the COVID-19 crisis. For now, it would be great if all faculty share how they responded to the COVID-19 crisis, lessons learned, challenges and creative solutions, new programs, etc. We will consider publishing creative and unique approaches, in articles of 500-800 words, in the Fall (November) edition of the journal.

References

1. Coronavirus Disease 2019 (COVID-19). Centers for Disease Control and Prevention [cited June 18, 2020]. Available from: https://www.cdc.gov/coronavirus/2019-ncov/faq.html#Basics
2. Tyrrell DA, Fielder M. Cold Wars: The Fight Against the Common Cold. Oxford University Press; 2002. 96 p.
3. Wang C, Horby PW, Hayden FG, Gao GF. A novel coronavirus outbreak of global health concern. Lancet. 2020 Feb 15;395(10223):470-473.
4. WHO Director-General's Opening Remarks at the Media Briefing on COVID-19 – 11 March 2020. World Health Organization [cited May 11, 2020]. Available from: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19—11-march-2020
5. COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU). Johns Hopkins University, Baltimore, MD [cited June 18, 2020]. Available from: https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6

Progressive Supranuclear Palsy: a Teaching Case Report

Julie Chao, OD, and Andrea Yiasemis, OD, FAAO | Optometric Education: Volume 45 Number 3 (Summer 2020)

Background

Progressive supranuclear palsy (PSP) is a neurodegenerative disorder with distinct clinical features including vertical supranuclear gaze palsy, frontal lobe cognitive decline, postural instability and progressive axial rigidity. First described in 1964 by Steele et al., PSP had been referred to historically as Steele-Richardson-Olszewski syndrome. They reported nine cases with the aforementioned findings, which veered from the typical presentation of idiopathic Parkinson's disease.[1] Since its initial characterization, PSP has been further categorized into different phenotypes with notable overlap with other neurodegenerative disorders. Early in the onset of the disease, patients with PSP are often misdiagnosed as having idiopathic Parkinson's disease.[2] Given that the average life expectancy following diagnosis is 5-10 years, it is imperative for practitioners to identify and manage the disease appropriately.[3,4] The three cases presented here highlight common ocular features of PSP and considerations for ophthalmologic management. The intended audience is third- and fourth-year optometry students, optometry residents and practicing optometrists.

Case Descriptions

Case 1

A 78-year-old man residing at a community living center presented to the eye clinic reporting that his vision in both eyes seemed to have slowly worsened over time. The patient's ocular history included toxic, nutritional optic neuropathy OD>OS secondary to long-term cocaine and alcohol abuse. His medical history included type 2 diabetes mellitus, osteopenia, liver steatosis, malignant prostatic tumor, hypertension, hyperlipidemia, spastic paraparesis, spinal stenosis and post-traumatic stress disorder. Medications included acetaminophen 650 mg, bicalutamide 50 mg, cholecalciferol, gabapentin 900 mg, simvastatin 40 mg, tamsulosin 0.4 mg and venlafaxine 150 mg.

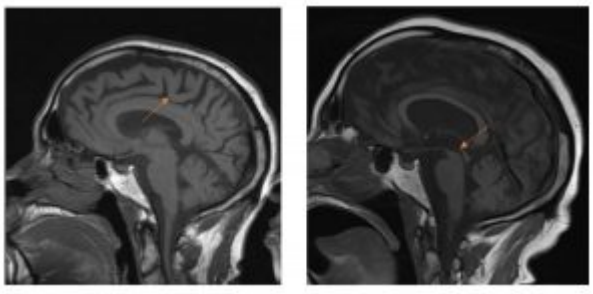


Figure 1. *MRI T-1 weighted images, sagittal view. Left: Initial study eight years prior with greater midbrain and colliculus volume. Right: Current study demonstrating "hummingbird sign" (midbrain atrophy).* Click to enlarge

Best-corrected visual acuities (BCVAs) were hand-motion OD and 20/50-1 OS. An afferent pupillary defect was noted OD. Evaluation of the patient's extraocular muscle motility exhibited a complete restriction of inferior gaze and a moderate restriction of vertical gaze. Of particular note, the vestibulo-ocular reflex (VOR), or "doll's head" reflex, was intact. The patient's low phonation and mild dysphagia made it difficult to acquire a proper history to ascertain whether he had been symptomatic for his restriction of gaze.

Pre-dilated intraocular pressures (IOPs) were measured as 15 mmHg OD and 19 mmHg OS. Slit-lamp biomicroscopy revealed interpalpebral corneal punctate epithelial erosions OU, grade 2+ nuclear and anterior cortical cataracts OU with cortical spokes within the visual axis OD. Dilated fundus exam revealed cup-to-disk ratios of 0.6 OD and 0.4 OS with diffuse disc pallor OD and temporal disc pallor OS. The peripheral fundus exam was unremarkable OU. The patient had difficulty comprehending instructions for confrontational or kinetic visual fields.

The patient's acquired oculomotor apraxia with intact VOR warranted further investigation to determine the presence or absence of a supranuclear palsy or degeneration. Magnetic resonance imaging (MRI) with and without contrast was ordered and revealed a classic "hummingbird sign" showing midbrain atrophy, as well as atrophy of the superior colliculus, which were not noted in the initial MRI study eight years prior **(Figure 1)**. The patient's primary care provider (PCP) was notified of the results, and a consultation to the neurology clinic for further evaluation of "possible PSP" was placed.

Case 2

A 61-year-old man presented for an eye examination reporting vertical binocular diplopia when reading for the past few weeks. The patient's medical history included type 2 diabetes mellitus, hyperlipidemia, psoriasis and recently diagnosed PSP. Prior to the diagnosis of PSP, the patient had experienced frequent falls and generalized muscle weakness over the course of three years. Within the course of the three years, the patient had been prescribed carbidopa-levodopa (Sinemet) and his condition was treated as atypical Parkinson's disease. At the time of his eye exam, he had discontinued carbidopa-levodopa due to a change in diagnosis from Parkinson's disease to PSP. The patient's ataxia had significantly progressed, and he was wheelchair-bound shortly before his eye examination. His most recent MRI demonstrated characteristic midbrain atrophy compared to prior studies **(Figure 2)**. Current medications included acetaminophen 650 mg, aspirin 81 mg, atorvastatin 40mg, gabapentin 300 mg qam and 600 mg qhs, lorazepam 1 mg, metformin 500 mg, sertraline 150 mg and tizanidine 2 mg.

BCVAs were 20/20 OD and 20/20 OS. Pupils were equal, round and reactive to light with no afferent pupillary defect present. Confrontational fields were full to finger counting OD and OS. Pre-dilated IOPs were 16 mmHg and 14 mmHg. Slit-lamp biomicroscopy findings revealed unremarkable eyelid and eyelash findings, small nasal pterygium minimally encroaching on the cornea, flat and avascular iridis and deep and quiet angles OU. Dilated fundus exam revealed 1+ nuclear cataract OS, cup-to-disc ratios of 0.45 round and 0.5 round OD, OS, respectively, and otherwise unremarkable posterior pole and peripheral retinal findings. Based on evaluation of the patient's vergences, exophoria greater at near than distance and a reduced near point of convergence were noted. Given the patient's symptom of diplopia at near, he was diagnosed with convergence insufficiency secondary to PSP. He was prescribed 2.5 prism diopters base out in single-vision near glasses for greater comfort when reading.

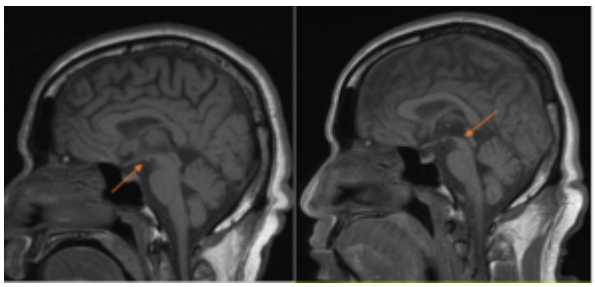


Figure 2. *MRI, T-1 weighted images, sagittal view. Left: Initial study three years prior with robust midbrain. Right: Most recent study demonstrating significant midbrain atrophy. Click to enlarge*

Four months after the initial eye examination, the patient was admitted to a nursing home and was examined at bedside at the request of the PCP and charge nurse due to a reported increase of falls. The patient reported that he preferred to use previously prescribed progressive addition lenses despite having diplopia at near. Evaluation of the extraocular muscles revealed normal lateral gaze and intact VOR but limited superior and inferior movement. Due to these concerns, the patient was educated on the importance of protecting his eyes given his unstable gait and re-prescribed single-vision distance and single-vision near glasses with Fresnel prism to adjust for changes in severity of his diplopia.

Case 3

A 75-year-old male referred for an eye exam by his neurologist presented to the eye clinic for a preoperative cataract evaluation. Doctors were unable to elicit any verbal complaints from the patient, as he had severe aphasia rooting from his diagnosis of PSP. His wife stated he had been less interactive with the family, and she was concerned he was unable to see their faces as well as he used to. The patient's neurologist had noted that improved vision may help reduce the possibility of agitation and delirium in demented patients. The patient's medical history included chronic cough (from pooled airway secretions), chronic microaspirations and previous cerebral vascular accident with right arm contracture. His medications included levothyroxine 0.15 mg, memantine 5 mg, ferrous sulfate 300 mg/mL, omeprazole 40 mg, albuterol 05% 2.5 mg/0.5mL, bisacodyl 10 mg, ascorbic acid 250 mg, cholecalciferol 1,000 units, acetaminophen 650 mg, levetiracetam solution 125 mg/1.25mL and glycopyrrolate 1 mg.

BCVAs were unobtainable due to the patient's poor cognitive state. Pupils were observed to be equal, round and reactive to light with no afferent pupillary defect present. The patient was unable to understand confrontational visual field testing. Upon extraocular muscle testing, he was noted to have restricted superior and inferior vertical gaze but intact VOR movement. Slit-lamp biomicroscopy findings revealed unremarkable eyelid and eyelash findings, flat and avascular iridis and deep and quiet angles OU. The lenses showed 3-4+ milky nuclear sclerotic cataracts OU. Dilated views by fundoscopy were poor and fleeting due to the patient's tendency to squeeze his eyelids shut with light exposure. The retina was grossly normal with optic nerve cup-to-disc ratios possibly larger than average but difficult to ascertain.

The ophthalmologists gathered from the limited data that the patient would be able to cautiously proceed with cataract extraction pending presurgical medical evaluation. Evaluation by the patient's pulmonologist determined that rhonchi, or low-pitched rattling sounds from the lungs, were present and suggested possible aspiration or respiratory infection. Given the

patient's demented mental status, general anesthesia would need to be administered, necessitating prolonged intubation and risking respiratory failure. Additionally, there was concern that coughing could disrupt postoperative sutures and result in a poor surgical outcome. The cataract surgery was thus postponed.

Education Guidelines

Learning objectives

1. Understand neurodegenerative diseases as they relate to ocular health
2. Become familiar with the ocular manifestations of PSP
3. Understand possible complications of general anesthesia when considering ocular procedures in patients with PSP or other neurodegenerative disease affecting motor function

Key concepts

1. Fundamental pathophysiology of PSP
2. Ocular effects of PSP and the optometrist's role in diagnosis
3. Management of patients with PSP

Discussion points

1. What is the pathophysiology of saccades and PSP?
2. What causes PSP?
3. How is PSP diagnosed?
4. What are the ocular signs and symptoms of PSP?
5. What are some differential diagnoses that should be considered in cases of suspected PSP?
6. What is the appropriate management of patients with PSP?
7. What is the prognosis of patients with PSP?

Literature review

PSP is the most common degenerative, atypical parkinsonian disorder, with a prevalence of 6.4 per 100,000 according to Schrag et al.[5,13] The incidence is reported to increase with age from 1.7 cases per 100,000 at 50-59 years to 14.7 per 100,000 per year at 80-99 years.[6,7] The mean age of diagnosis is approximately 65 years, with no racial or sex predilection. No significant risk factors for developing PSP have been identified.[3]

Discussion

Teaching instructions: Participants should read each question and consider how they would respond, then read the information provided in the text. Participants may work together in small groups or individually, either in real time or as part of a homework assignment. If working in groups, participants may split into three groups with each group focusing on one case or each group working on all three cases. Learning objectives can be assessed by comparing participants' responses to the questions provided. This case may also be presented as a PowerPoint presentation detailing the case presentation, learning objectives, key concepts, literature review and discussion points.

What is the pathophysiology of saccades and PSP?

For horizontal and vertical saccades to be initiated, excitatory burst neurons (EBNs) in the brainstem generate a burst of neuronal discharge known as the pulse. The EBNs for horizontal saccades are located in the paramedian pontine reticular formation. The EBNs for vertical and torsional saccades are located in the rostral interstitial medial longitudinal fasciculus (RIMLF) and interstitial nucleus of Cajal. Once the pulse fires to the intended agonist muscle, antagonist muscles are relaxed.[8]

PSP results from an aggregation of abnormally phosphorylated tau proteins. Tau proteins aid in axonal transport and support neuronal microtubules. Localized accumulation of the irregular tau proteins form what are known as neurofibrillary tangles.[9] In addition to the tauopathy, PSP degenerates dopaminergic neurons and cholinergic neurons, lending to loss of basal ganglia, cerebral cortex and, most clinically characteristic, brainstem structures. Structures within the brainstem that atrophy are the dorsal midbrain, notably the midbrain tegmentum and pedunculopontine nucleus, which lends to postural stability, and the motor nuclei of the cranial nerves in advanced stages of the disease. Given the atrophy of the midbrain tegmentum, the RIMLF is greatly affected, which decreases the presence of vertical EBNs, and an inability to initiate vertical saccades ensues.[8]

What causes PSP?

Although no definitive genetic factors have been identified, recent studies suggest there may be a genetic susceptibility in patients with mutations of the tau gene. PSP is currently considered a "tauopathy."[10]

How is PSP diagnosed?

The diagnostic criteria for PSP, which were revised in 2017 by the International Parkinson and Movement Disorder Society, must include all "basic features": sporadic occurrence, age 40 years or older at onset of first PSP-related symptom, and gradual progression of PSP-related symptoms.[11,12] PSP-related symptoms include ocular motor dysfunction, postural instability, akinesia and cognitive dysfunction. The category of ocular motor dysfunction is further stratified to include vertical supranuclear gaze palsy, slow vertical saccades and frequent macro square wave jerks or "eyelid opening apraxia." In this delineated criterion, the highest level of certainty for each category is defined as vertical supranuclear gaze palsy, repeated unprovoked falls within three years, progressive freezing of gait within three years, and speech or language disorder that presents as some variant of primary progressive aphasia, respectively. Supportive features that may increase diagnostic confidence, but do not alone suggest a diagnosis, include levodopa resistance, dysphagia, photophobia, and hypokinetic, spastic dysarthria.

Clinical forms of PSP have arisen since its original description in 1964. The original cases presented by Steele-Richardso--Olszewski have been classified as Richardson Syndrome (PSP-RS), which is characterized by postural instability, vertical gaze palsy and cognitive dysfunction. Eight other clinical variants have been described based on the severity and nature of their neurological signs.[11]

The gold standard for diagnosing PSP is a comprehensive, post-mortem neuropathological examination to identify the presence of neurofibrillary tangles. Because a definitive diagnosis requires a post-mortem exam, it is crucial for an eyecare provider to be able to identify oculomotor restrictions and make appropriate clinical recommendations for the patient's systemic care.[12]

What are the ocular signs and symptoms of PSP?

Patients with PSP typically present with horizontal or vertical diplopia or asthenopia while reading secondary to convergence insufficiency, horizontal or vertical gaze palsy.[13] Patients may also exhibit impaired slow phase responses of their vertical optokinetic response, as well as slowed volitional saccades.[14] In a few studies, abnormal acoustic-startling reflex (orbicularis oculi response to high-intensity stimulation of the median nerve) and apraxia of eyelid opening have been observed in patients diagnosed with PSP.[15-18] A decrease in blink frequency may cause symptoms of dry eye, including blurred vision, foreign body sensation, burning or irritation. Appropriate evaluation of extraocular muscle motility and near point of convergence as well as slit-lamp examination to evaluate the tear film and corneal integrity are of particular importance.

What are some differential diagnoses that should be considered in cases of suspected PSP?

From an ocular standpoint, it is important to determine the etiology of a patient's presenting symptoms of double vision when reading or limitation of gaze rather than assuming such presentations are idiopathic or, as observed in case 2 reported above, presbyopia-associated convergence insufficiency. In assessing these complaints, the clinician must elicit a thorough case history including recent falls or postural changes and memory changes. Additionally, it is critical to carefully assess extraocular muscle movement, saccades, phorias and vergences at distance and near. Forced duction evaluation is particularly valuable in differentiating a mechanical vs. a neurodegenerative or vascular cause. The posterior thalamo-subthalamic paramedian artery, which stems from the posterior cerebral artery, supplies the RIMLF. Thus, an infarction of this artery may result in a superior gaze palsy.[19] Neoplasms, particularly pineal gland tumors, may also lead to vertical gaze palsies.[19] Other vertical gaze palsy conditions include Neimann-Pick type C, an autosomal-recessive condition in which cholesterol and lipids accumulate, dorsal midbrain syndrome, Whipple disease, and midbrain infarction.[19]

As previously noted, PSP is often misdiagnosed early in its course as Parkinson's disease. It shows similar symptoms to Parkinson's, dementia with Lewy bodies (DLB) and multiple system atrophy (MSA). Parkinson's disease is a neurodegenerative disorder with characteristic skeletal muscle tremor, rigidity and akinesia, all of which are features observed in PSP.[20] However, PSP typically involves greater cognitive dysfunction and speech disturbance than Parkinson's disease. A study by Song et al. assessed patients with MSA, Parkinson's disease and PSP. Results showed that 73% of patients with PSP had gaze abnormalities, a characteristic that was absent in Parkinson's disease and MSA.[21] Song also found that patients with PSP and MSA had a poorer response to levodopa, which is a staple treatment for Parkinson's disease.

MSA is defined as an "adult-onset, sporadic, progressive neurodegenerative disease" with "parkinsonian features, cerebellar ataxia, autonomic failure, urogenital dysfunction, and corticospinal disorders" by the Second Consensus Statement on the

Diagnosis of MSA.[22,23] Although difficult to definitively differentiate from PSP, any sign of autonomic dysfunction would steer the diagnosis towards MSA.

DLB is defined by the 2017 Dementia with Lewy Bodies Consortium as a disease of "progressive cognitive decline of sufficient magnitude to interfere with normal social or occupational functions, or with usual daily activities." In DLB, patients have "recurrent visual hallucinations that are typically well-formed and detailed," rapid eye movement (REM) sleep behavior disorder, and "features of parkinsonianism."[24] Gait abnormalities, gaze apraxia and saccadic dysfunction may be present in both PSP and DLB, but visual hallucinations are a hallmark feature of DLB.[25,26]

Various presenting signs and symptoms overlap between PSP and other neurodegenerative disorders, which makes PSP diagnosis reliant on the clinical findings centered around the 2017 Movement Disorder Society criteria. Neuroimaging such as MRI may be a helpful supplement for diagnosis. Various studies report abnormalities on MRI demonstrating midbrain atrophy, third ventricle dilation, T2-periaqueductal hyperintensities and frontal and temporal atrophy. One hallmark feature of PSP on MRI is the "hummingbird sign" or "penguin sign" demonstrating midbrain atrophy. Most useful for differentiating PSP from Parkinson's disease or other atypical Parkinson's diseases are the midbrain-to-pontine area ratio, which tends to be lower in PSP patients, and the magnetic resonance parkinsonism index (MRPI), which is greater in PSP patients. The MRPI is a value calculated by determining atrophy of the midbrain, superior cerebellar peduncle, pons and middle cerebellar peduncle.[27,28] Another promising diagnostic method is utilizing positron emission tomography scanning to track the tau protein THK5351 and determine the presence of tau aggregates specific to PSP.[29] This diagnostic tool, however, is predominantly used in research and often not clinically performed due to cost constraints.

What is the appropriate management of patients with PSP?

Eyecare providers are crucial in determining the presence or absence of gaze palsies, which aids in the differentiation of PSP. Once an abnormality is determined, a referral to the patient's PCP and neurologist should be made.

Patients with PSP often have limited benefit from levodopa therapy, as opposed to patients with Parkinson's disease. In a study by Williams et al. investigating 91 pathologically confirmed cases of PSP, 32% of patients presented with a response to levodopa, defined as a 30% or greater improvement in symptoms.[30] There are no successful pharmacological treatment options targeting the disease process, and management centers around symptomatic care. A few case reports have demonstrated some efficacy of botulinum toxin injected into the orbicularis oculi for apraxia of eyelid opening, into upper limbs to improve rigidity and into cricopharyngeal muscle for dysphagia.[31-34] Additional intervention from an interdisciplinary care team consisting of speech, physical and occupational therapists is necessary to facilitate greater independent activities of daily living.

Following diagnosis of PSP, the optometrist may play a role in the patient's care, particularly to address diplopia and dry eye symptoms. A study by Reddy et al. found that corneal sensitivity was reduced in patients with PSP, with 71% reporting they did not have dry eyes. However, evaluation of the tear firm revealed reduced tear break-up time compared to the control group.[35] Even without patent report of dry eye symptoms, it is important for the optometrist to manage the patient's dry eyes with artificial tears and lubricating ointment or gel formulations for severe exposure keratopathy. Although few reports demonstrate alleviation of double vision when reading with "mirror prism," we found that Fresnel prisms were particularly useful for alleviating the progressive double vision experienced by the patient in case 2.[36,37]

What is the prognosis for patients with PSP?

PSP is a rapidly neurodegenerative condition with a poor prognosis. A study by Cosseddu et al. evaluated 100 patients with PSP and found that the average disease duration following diagnosis was 8.25 years.[3] Cosseddu found that patients with dementia at the time of diagnosis had a shorter survival time than those without dementia, with no other significant predictors.[3] The most common causes of death for patients with PSP are respiratory-related, with the most frequent complication being aspiration pneumonia.[38] Given the high frequency of respiration complications, surgery requiring general anesthesia should be given significant consideration due to the potential for respiratory failure.

Conclusion

Optometrists may play a critical role in recognizing characteristic features of PSP and managing concomitant ocular symptoms that may arise. Although no pharmacologic therapy halts progression of the disease, a multidisciplinary team can provide patients and their caretakers with the tools to maximize quality of life and minimize debilitating symptoms.

References

1. Steele JC, Richardson JC, Olszewski J. Progressive supranuclear palsy. A heterogeneous degeneration involving the brain

stem, basal ganglia and cerebellum with vertical gaze and pseudobulbar palsy, nuchal dystonia and dementia. Arch Neurol. 1964 Apr;10:333-59.
2. Joutsa J, Gardberg M, Röyttä M, Kaasinen V. Diagnostic accuracy of Parkinsonism syndromes by general neurologists. Parkinsonism Relat Disord. 2014 Aug;20(8):840-4.
3. Cosseddu M, Benussi A, Gazzina S, et al. Natural history and predictors of survival in progressive supranuclear palsy. J Neurol Sci. 2017 Nov 15;382:105-107.
4. Glasmacher SA, Leigh PN, Saha RA. Predictors of survival in progressive supranuclear palsy and multiple system atrophy: a systematic review and meta-analysis. J Neurol Neurosurg Psychiatry. 2017 May;88(5):402-411.
5. Schrag A, Ben-Shlomo Y, Quinn NP. Prevalence of progressive supranuclear palsy and multiple system atrophy: a cross-sectional study. Lancet. 1999 Nov 20;354(9192):1771-5.
6. Bower JH, Maraganore DM, McDonnell SK, Rocca WA. Incidence of progressive supranuclear palsy and multiple system atrophy in Olmsted County, Minnesota, 1976 to 1990. Neurology. 1997 Nov;49(5):1284-8.
7. Chiu WZ, Kaat LD, Seelaar H, et al. Survival in progressive supranuclear palsy and frontotemporal dementia. J Neurol Neurosurg Psychiatry. 2010 Apr;81(4):441-5.
8. Kato N, Arai K, Hattori T. Study of the rostral midbrain atrophy in progressive supranuclear palsy. J Neurol Sci. 2003;210(1-2):57-60.
9. Bancher C, Lassmann H, Budka H, et al. Neurofibrillary tangles in Alzheimer's disease and progressive supranuclear palsy: antigenic similarities and differences. Microtubule-associated protein tau antigenicity is prominent in all types of tangles. Acta Neuropathol. 1987;74(1):39-46.
10. Stanford PM, Halliday GM, Brooks WS, et al. Progressive supranuclear palsy pathology caused by a novel silent mutation in exon 10 of the tau gene: expansion of the disease phenotype caused by the tau gene mutations. Brain. 2000 May;123 (Pt 5):880-93.
11. Höglinger GU, Respondek G, Stamelou M, et al. Clinical diagnosis of progressive supranuclear palsy: the movement disorder society criteria. Mov Disord. 2017 Jun;32(6):853-864.
12. Litvan I, Agid Y, Calne D, et al. Clinical research criteria for the diagnosis of progressive supranuclear palsy (Steele-Richardson-Olszewski syndrome): report of the NINDS-SPSP international workshop. Neurology. 1996 Jul;47(1):1-9.
13. Williams DR, Lees AJ. Progressive supranuclear palsy: clinicopathological concepts and diagnostic challenges. Lancet Neurol. 2009 Mar;8(3):270-9.
14. Chen AL, Riley DE, King SA, et al. The disturbance of gaze in progressive supranuclear palsy: implications for pathogenesis. Front Neurol. 2010 Dec 3;1:147.
15. Shaikh AG, Factor SA, Juncos J. Saccades in progressive supranuclear palsy–maladapted, irregular, curved, and slow. Mov Disord Clin Pract. Sep-Oct 2017;4(5):671-681.
16. Gironell A, Kulisevsky J, Roig C, Pascual-Sedano B, Rodríguez-Fornells A, Otermin P. Diagnostic potential of acoustic startle reflex, acoustic blink reflex, and electro-oculography in progressive supranuclear palsy: a prospective study. Mov Disord. 2003 Nov;18(11):1273-9.
17. Valls-Solé J, Valldeoriola F, Tolosa E, Marti MJ. Distinctive abnormalities of facial reflexes in patients with progressive supranuclear palsy. Brain. 1997 Oct;120 (Pt 10):1877-83.
18. Grandas F, Esteban A. Eyelid motor abnormalities in progressive supranuclear palsy. In: Tolosa E, Duvoisin R, Cruz-Sanchez FF, editors. Progressive supranuclear palsy: diagnosis, pathology, and therapy. Vienna: Springer;1994. p.33-41.
19. Lloyd-Smith Sequeira A, Rizzo JR, Rucker JC. Clinical approach to supranuclear brainstem saccadic gaze palsies. Front Neurol. 2017 Aug 23;8:429.
20. Lopez G, Bayulkem K, Hallett M. Progressive supranuclear palsy (PSP): Richardson syndrome and other PSP variants. Acta Neurol Scand. 2016 Oct;134(4):242-9.
21. Pasternak JJ, Lanier WL. Diseases affecting the brain. In: Hines RL, Marschall KE, editors. Stoelting's anesthesia and co-existing disease. Philadelphia: Elsevier; 2018. p. 265-303.
22. Williams DR, Warren JD, Lees AJ. Using the presence of visual hallucinations to differentiate Parkinson's disease from atypical parkinsonism. J Neurol Neurosurg Psychiatry. 2008 Jun;79(6):652-5.
23. Gilman S, Wenning GK, Low PA, et al. Second consensus statement on the diagnosis of multiple system atrophy. Neurology. 2008 Aug 26;71(9):670-6.
24. Liscic RM, Srulijes K, Gröger A, Maetzler W, Berg D. Differentiation of progressive supranuclear palsy: clinical, imaging and laboratory tools. Acta Neurol Scand. 2013 May;127(5):362-70.
25. Song YJ, Huang Y, Halliday GM. Clinical correlates of similar pathologies in parkinsonian syndromes. Mov Disord. 2011 Feb 15;26(3):499-506.
26. McKeith IG, Boeve BF, Dickson DW, et al. Diagnosis and management of dementia with Lewy bodies: fourth consensus report of the DLB Consortium. Neurology. 2017 Jul 4;89(1):88-100.
27. Hussl A, Mahlknecht P, Scherfler C, et al. Diagnostic accuracy of the magnetic resonance parkinsonism index and the midbrain-to-pontine area ratio to differentiate progressive supranuclear palsy from Parkinson's disease and the Parkinson variant of multiple system atrophy. Mov Disord. 2010 Oct 30;25(14):2444-9.

28. Massey LA, Jager HR, Paviour DC, et al. The midbrain to pons ratio: a simple and specific MRI sign of progressive supranuclear palsy. Neurology. 2013 May 14;80(20):1856-61.
29. Respondek G, Levin J, Höglinger GU. Progressive supranuclear palsy and multiple system atrophy: clinicopathological concepts and therapeutic challenges. Curr Opin Neurol. 2018 Aug;31(4):448-454.
30. Williams DR, Silva R, Paviour DC, et al. Characteristics of two distinct clinical phenotypes in pathologically proven progressive supranuclear palsy: Richardson's syndrome and PSP-parkinsonism, Brain. 2005 Jun;128 (Pt 6):1247-58.
31. Lepore V, Defazio G, Acquistapace D, et al. Botulinum a toxin for the so-called apraxia of lid opening. Mov Disord. 1995 Jul;10(4):525-6.
32. Piccione F, Mancini E, Tonin P, Bizzarini M. Botulinum toxin treatment of apraxia of eyelid opening in progressive supranuclear palsy: report of two cases. Arch Phys Med Rehabil. 1997 May;78(5):525-9.
33. Polo KB, Jabbari B. Botulinum toxin-A improves the rigidity of progressive supranuclear palsy. Ann Neurol. 1994 Feb;35(2):237-9.
34. Alfonsi E, Merlo IM, Ponzio M, et al. An electrophysiological approach to the diagnosis of neurogenic dysphagia: implications for botulinum toxin treatment. J Neurol Neurosurg Psychiatry. 2010 Jan;81(1):54-60.
35. Reddy VC, Patel SV, Hodge DO, Leavitt JA. Corneal sensitivity, blink rate, and corneal nerve density in progressive supranuclear palsy and Parkinson disease. Cornea. 2013 May;32(5):631-5.
36. Krohel GB, Tobin DR, Hartnett ME, Barrows NA. Divergence paralysis. Am J Ophthalmol. 1982 Oct;94(4):506-10.
37. Weisz RR, Richer SP, Jordan M, Tucker EG. Case report: prismatic redirection of vision for progressive supranuclear palsy. J Am Optom Assoc. 1991 Jul;62(7):537-9.
38. Litvan I, Mangone CA, McKee A, et al. Natural history of progressive supranuclear palsy (Steele-Richardson-Olszewski syndrome) and clinical predictors of survival: a clinicopathological study. J Neurol Neurosurg Psychiatry. 1996 Jun;60(6):615-20.

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