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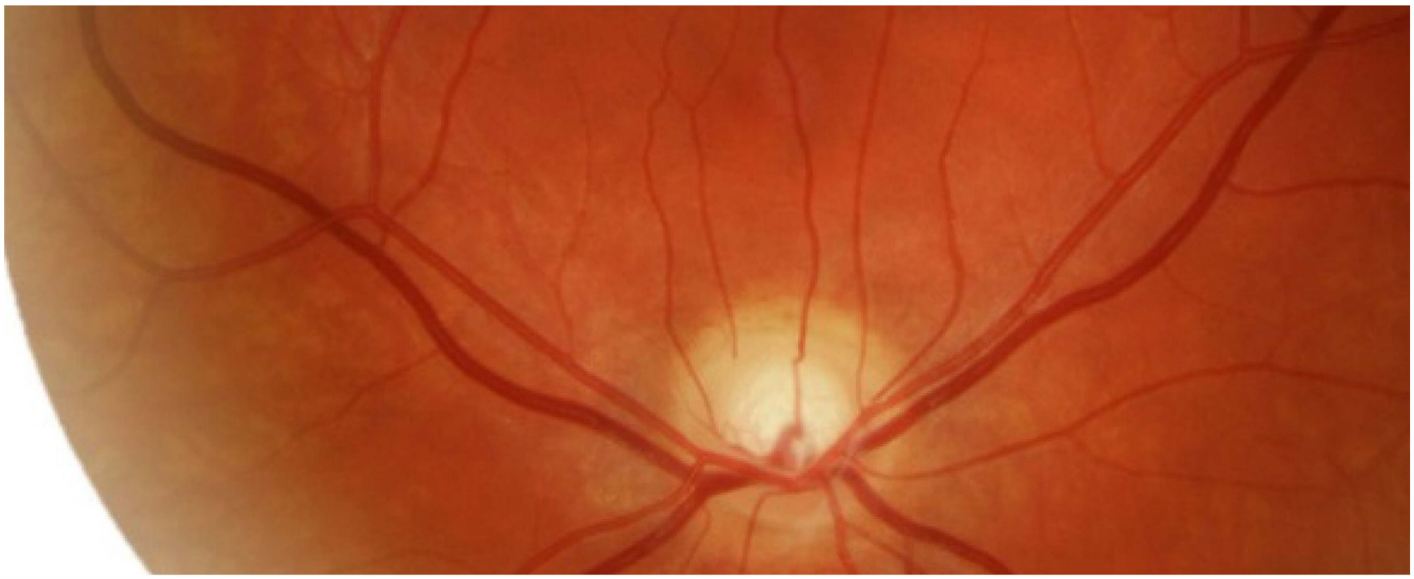

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Do Our Students Really Possess Information Literacy?

Aurora Denial, OD, FAAO | Optometric Education: Volume 41 Number 2

Aurora Denial, OD, FAAO

In 2011, the Board of Directors of the Association of Schools and Colleges of Optometry (ASCO) approved an updated "Attributes of Students Graduating from Schools and Colleges of Optometry" report. The report represents contemporary thinking about the requisite competencies for new graduates of optometry degree programs. It states that graduates are "responsible for ongoing self-learning and for remaining current and competent in their knowledge and skills."[1] Additionally, it states that "The school or college of optometry shall ensure that before graduation each student will have demonstrated the ability to access evidence-based knowledge (including through the use of information technology) and manage information, and to apply that information in making decisions about patient care and health care delivery." As clinicians and educators we all have experienced the explosion in the availability of information on the Internet. This information is a valuable resource for all health care professionals and students. However, there may be a gap in students' ability to use these tools.

Though not new, the concepts of "information literacy," "fluency in technology" and "computer literacy" have recently received a lot of attention in higher education. The concept of information literacy involves more than the ability to look up a topic on the Internet. It includes critical thinking related to determining the purpose of gaining information, identifying assumptions, critically evaluating literature, determining biases, forming conclusions and evaluating implications. According to the Association of College and Research Libraries (ACRL), computer literacy focuses on the "rote learning of specific hardware and software applications, while 'fluency with technology' focuses on understanding the underlying concepts of technology and applying problem-solving and critical thinking to using technology."[2] Although this definition introduces the concepts of critical thinking and problem-solving, they are applied directly to technology. In 2000, the ACRL defined information literacy as "a set of abilities requiring individuals to recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information."[2] In 2015, the organization presented an expanded definition: "Information literacy is the set of integrated abilities encompassing the reflective discovery of information, the understanding of how information is produced and valued, and the use of information in creating new knowledge and participating ethically in communities of learning."[3] Information literacy allows doctors more control over their learning and the ability to stay current.[2]

Information Literacy Must Be Taught, Even to Millennials

The ability to identify appropriate databases, efficiently use the databases, critically evaluate clinical studies and appropriately reference sources can be particularly daunting skills for students. Because most students in the millennial generation are savvy in the use of technology, it is easy to assume that navigating the Internet for information related to the acquisition and use of knowledge would come naturally. In my experience, many students are significantly lacking in information literacy skills. Therefore, these skills need to be taught in an organized and concrete manner and then practiced. Projects that require students to research ocular conditions, use evidence-based practice and evaluate information should be incorporated into every year of the curriculum. The utilization of information literacy skills should become a habit of mind, so it is automatic. The efficient utilization of information is particularly important in the clinical environment. In today's world, the emphasis in most clinical environments is productivity. If obtaining and using information is not a habit, it has potential to interfere with productivity and may not be utilized. Developing a culture of information literacy while also focusing on teaching, patient care and productivity can be challenging for clinical faculty, but students must be prepared to use these skills in the clinical environment, and faculty must act as role models.

How Does Your Institution Foster Information Literacy?

What is the best method for teaching information literacy skills to our students? Are we achieving the goals set forth by ASCO? Are we evaluating outcomes and disseminating information so that best practices can be achieved? A search of PubMed,

VisionCite and Education Resources Information Center (ERIC) using the terms “information literacy,” “computer literacy,” and “optometry or optometric education” produced only a few articles in the profession of optometry. What is your institution doing to teach, utilize and reinforce information literacy skills?

References

1. Smythe J, Daum K. Attributes of students graduating from schools and colleges of optometry: a 2011 report from the Association of Schools and Colleges of Optometry. Optometric Education. 2011;37(1):5-10.

2. Association of College and Research Libraries. Information Literacy Competency Standards for Higher Education Chicago (IL) 2000 [cited 2016 January 26]. Available from: http://www.ala.org/acrl/standards/informationliteracycompetency.

3. Association of College and Research Libraries. Framework for Information Literacy for Higher Education. Chicago (IL) 2015 [cited 2016 January 26]. Available from: http://www.ala.org/acrl/standards/ilframework.

Deadline Extended for Upcoming International Optometric Education Theme Edition

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International Optometric Education: Global Expansion and Transformation

(New deadline to submit papers: June 1, 2016)

Over the past 20 years, the profession of optometry has undergone dramatic global changes: expanding scope of practice, increasing quality assurance expectations, significant diversification of students, and the accelerating impact of information technology. Underpinning these changes has been the critical role of international optometric education in supporting and catalyzing this transformation. The same global forces that are driving the transformation of the profession are also creating challenges and opportunities for optometric educational institutions. Student, faculty, patient and institutional expectations are converging and greater accountability is expected. This includes such areas as clinical competency, professional ethics, interprofessional collaboration and curricular innovation.

This theme issue builds on the work of the ASCO International Optometric Education Committee and International Optometric Educators Special Interest Group (SIG).

Authors are invited to submit scholarly articles that address this theme and underscore innovation and the impact educational institutions are having on their students, the profession and the communities they serve. We encourage scholarly articles that are translational and promote global dissemination.

We are pleased to have Anthony F. Di Stefano, OD, MEd, MPH, Salus University, serve as the Guest Editor of this issue. For more information, please e-mail journal Editor Aurora Denial, OD, FAAO.

Upcoming Theme Issue Will Focus on Diversity and Cultural Competence

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Optometric Education announces that a future edition of the journal will focus on the theme of Diversity and Cultural and Linguistic Competence. The edition will focus on the diversity of our students, faculty and profession and all aspects of cultural and linguistic competence, including professional, organizational and individual responsibility.

The deadline to submit articles for this theme edition is Dec. 31, 2016. For additional information, contact Gary Chu, OD, or journal Editor Aurora Denial, OD, FAAO.

Industry News

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Coming in April

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Stay tuned to your Inbox for the announcement that the Spring 2016 issue of *Eye on Education* — the online newsletter from the Association of Schools and Colleges of Optometry (ASCO) — is available.

The issue will include the latest news about ASCO initiatives and activities as well as items of interest from the schools and colleges of optometry and the Association's corporate partners.

Also: Visit ASCO's website to take advantage of a variety of resources, including the recently posted "Career Opportunities for ODs in Academia: Teaching & Research Needs," a PowerPoint module that explores the need for increasing the faculty ranks at optometric institutions.

Teaching Optometry Students How to Study Actively

Nancy B. Carlson, OD, FAAO | Optometric Education: Volume 41 Number 2

Students enter optometry college with varying undergraduate backgrounds and a wide variety of study skills. They are eager to learn but are not always prepared to learn for mastery: the deeper understanding of material that can be recalled and applied later to clinical situations. In optometry college, cramming for exams and/or trying to memorize everything just does not work. In a study of first-year optometry students, McGinley, Carlson and Hoppe[1] (2008) found the study skills students reported using in undergraduate college would be inadequate for the volume and intensity of work that would be expected of doctoral level students in their didactic program. In a follow-up study, McGinley and Carlson[2] (2010) found that over the course of the first year in their professional program, a significant number of students improved their time management skills and their consistency in studying and decreased cramming.

First-year optometry students spend approximately 30 hours per week in lecture, labs, seminar and clinical activities. Students take seven or more courses during their first semester, a larger load of courses than most of them had as undergraduates. Furthermore, all courses are important, and none can be largely ignored successfully. Time management becomes crucial when so much time has already been committed to the academic schedule. Students must learn how to study efficiently, continue to take care of their health with good nutrition and exercise, and have some fun. Faculty can help students who need to improve their study skills through individual meetings or group presentations and discussions. This Educator's Podium explores study methods that have been successfully used by students in health professions programs and makes recommendations for faculty and students for the didactic portion of their programs.

What Can Be Learned from the Literature?

The journal *Optometric Education* published only three articles related to study skills for optometry students in the past five years.[3-5] Yet optometric educators know that many of their students need help. As soon as the first midterm exams are over, there are always students wanting to know why they have done so poorly when they have put so much time and effort into preparing. A discussion with these students often reveals that they have only studied for two to three nights before the exam rather than throughout the term; their study method is to re-read their course handouts or notes several times; they have not done the required reading or the recommended reading; and have not studied with anyone else in their class. These students clearly need to learn to study differently. They need to be more actively engaged with the material they are learning in order to truly master it. While memorization has a place in optometry college, deeper learning or mastery is also needed to be able to recall information later and apply it to patient care.

In the 1990s, Bonwell and Eisen[6] promoted active learning techniques for the classroom and for studying. Active learning helps students to analyze, synthesize and evaluate course material and leads to longer retention of information to use later in clinical situations. Re-reading course notes or trying to memorize everything in the course is very passive and does not promote long-term retention of material.

Freeman, Eddy, McDonogh, Smith et al.[7] (2014) reviewed 225 studies comparing traditional lecture to active learning activities and found that student performance improved an average of 6% if they were engaged in active learning activities rather than just passively listening to lectures. Students who did not participate in active learning were 1.5 times more likely to fail the course they were taking.

Prince[8] (2004) looked at the effectiveness of active learning among engineering students. He found that students remember more content if some active learning activities are introduced in lecture and if they engage in collaborative and cooperative learning. One strategy he recommends is having the lecturer pause for a few minutes during class while students work with each other to make a brief summary in their own words to clarify their notes on the presentation. This has been shown to improve student long-term retention of basic concepts. Prince also reports on studies done by Johnson, Johnson and Smith[9,10] (1998) that show that academic achievement and self-esteem improved among students who worked collaboratively with one another.

Active Study Skills

While few articles have been written for optometry students about study skills, many papers and websites can be found for college students in general and for medical students and other health professions students. These articles, including those written by community college faculty, can be very useful for teaching optometry. Heller and Marchant[11] (2015) recommend a

structured, content-learning approach in their introductory psychology course that resulted in the students in the intervention group performing significantly better on three exams and achieving higher course grades for the semester. Heys and Wawrzynski[12] (2013) presented results of a study that showed that male students who are peer educators show significant growth not only in the content area they are teaching but also in interpersonal skills, awareness of diversity and communication skills. This supports the report by Prince on cooperative and collaborative work among students. McDaniel[13] (2014) presents a list of five do's and don'ts to promote critical thinking rather than just teaching to the test. These papers, and many others, can help faculty to teach students efficient ways of learning.

Bonwell and Eisen[14] (1991) recommend techniques to use in the classroom setting to actively engage students in discussion and in learning the material during class. Active learning can be done in or out of class, by individual students or by a group of students, and either orally or in writing. Active learning promotes the deeper type of learning needed by healthcare students. Re-reading notes many times, a strategy that may have worked for undergraduates, does not engage students fully enough to help them to master the material.

Much of the information on how to study in medical school emphasizes active study skills. Some of the information is in journal articles and some on websites, frequently from the student services offices at medical schools. For example, in her article "How to Drink from a Fire-hose without Drowning," Apperson[15] describes the problem with studying that medical students face as similar to that of optometry students: a large volume of material that must be mastered with less available study time than they had as undergraduates. She recommends active study techniques including knowing the big picture by scanning notes and/or PowerPoint presentations before class, organizing information by annotating class notes right after class, memorizing what is necessary and frequently reviewing it, and trying to apply information to more complex clinical situations through quizzes and practice problems. Jacobs[16] (2014) gives the same list as Apperson but for pharmacy students.

Augustin[17] (2014) recommends repetition of information that must be memorized. In addition, testing the material on several different occasions helps students to retain the information. Feedback given after each testing session shows the students what to focus on to improve quiz or test scores for the next time and leads to longer retention. Active recall such as writing what has been learned rather than passively re-reading it also improves long-term retention. Quizzes given before information has been presented in lecture helps students focus on what they need to learn and aids in retention of concepts. Augustin reported on an experiment by Storm, Bjork and Storm[18] (2010) that showed students who spaced their study at differing intervals retained more than students who studied the same material on a fixed interval schedule.

The website for the Academic Skills Center at Dartmouth College[19] lists the following for improving concentration, memory and motivation: study in chunks, study in daylight hours, study actively, and find the right place to study. The site also includes handouts, videos and links to other websites on how to study. The handout on How to Study Actively recommends reading before going to class, attending class, asking questions, reviewing notes right after class, outlining major topics, asking yourself questions, reading the text, doing homework and reviewing and integrating the material.

Petersen of The Albert Einstein College of Medicine[20] (2012) reported that nine out of 10 students find that working with other students improves their understanding and their exam scores. Working with a group helps a student figure out what he knows and what he does not know. Petersen recommends groups of three to four students with one serving as a monitor at each meeting of the group. The group should agree on the amount of time they will meet and what will be covered at the study session. Students should prepare for the session by bringing a list of key points to be covered and a list of their own areas of confusion. Students can teach each other and learn from each other through oral quizzes at group study. Study groups help students know what material they know well and what they need to work on. Being part of a study group also decreases procrastination: The student has to be prepared to work with others before the group meets.

The social media site KevinMD.com[21] (2012) gives the following advice to new medical students: cramming is bad; avoid study groups; focus, dammit; don't get down on yourself; learn what medicine is all about. While "avoid study groups" is in contrast to the advice from Dr. Petersen at Einstein Medical College, there is no one study method that will work for all students. "Cramming is bad" is a more direct way of saying that health professionals must learn for mastery and be able to recall information and apply it to patient care.

In his editorial "What Makes a Good Teacher? Lessons from Teaching Medical Students," Markert[22] (2001) says, "Learning is seen not as the storage of information but as the continuous process of filtering new knowledge through the structures we have developed from prior learning and

TABLE 1
Active Study Strategies for Optometry Students

Review notes/handouts before lecture and mark the areas where you have questions
Attend class and take notes on your handouts to clarify concepts
Review the class notes after class
Condense notes into main points and use these to review often
Make flashcards for information that must be memorized: e.g., definitions, formulas, and review often
Study with a group; be sure everyone in the group is participating
Study as though you will have to explain the topic to someone else and do this often in group study; be sure everyone participates
Write questions for your study group and share them; think about what you think the professor will ask you on an exam
To maximize your lab experience, review the lab handout before lab, review relevant notes before lab, and do any assigned reading before lab
Review lab handouts after they have been graded and returned to you
Practice! Practice! Practice!
Ask for help when you need it (from your professor or from Student Services)
Review often
Stay healthy! (eat well, exercise, meditate)
Have fun!

Click to enlarge

experience." We need to help our students with study skills that will set them up for the lifelong learning that is needed in health care in the 21st century and give them ways to attach new information to previously learned information to make it easier for them to remember. Active learning techniques foster this.

Brown, Roediger and McDaniel[23] (2014) state, "Elaboration is the process of giving new material meaning by expressing it in your own words and connecting it with what you already know. The more you can explain about the way your new learning relates to your prior knowledge, the stronger your grasp of the new learning will be and the more connections you create that will help you remember it later." Students can do this by summarizing what they know about a topic during their group study sessions and when they condense their notes for later review and study.

"See one, Do one, Teach one,"[24] is a popular learning strategy in medical education. The student observes what he will be doing, then does it with an expert watching and providing feedback. Finally, the student, in his own words, teaches what he has learned to another student. This strategy encourages active learning and helps the student to self-reflect on what he has learned. Simulations and web-based learning have replaced this strategy to some extent, especially for learning techniques that might be invasive or harmful to the patient. However, the basic principles in this learning method are sound and still useful.

Active Teaching of Active Learning

Although optometry students are college graduates when they start optometry college, they are not always prepared for the volume, intensity and long-term retention that is needed to study optometry successfully. Faculty need to help students acquire study skills along with acquiring new knowledge. **Table 1** shows a summary of many of the active study techniques that were presented in this Educator's Podium and can be given to first-year optometry students during orientation to help them hit the ground running and "not drown while trying to drink from a fire-hose." Even the well-prepared students can benefit from learning new ways to study and make their studying more efficient. Students who are not doing as well as they expected can benefit from changing their study habits to more active techniques because studying in the same way they have been is likely to result in the same disappointing outcome.

Students also need to be reminded that they have to take care of themselves and remain healthy to maximize their learning. They need to eat three nutritious meals per day and maintain an exercise program to help reduce stress. Meditation is also a great stress reliever. YouTube[25] contains numerous sites for both long and short meditation sessions. The sites for "Mandala Meditation" have soothing music, great kaleidoscope graphics, generally play for less than 10 minutes and are very appealing to students, even those who have never meditated before. Students who meditate every day and also right before an exam generally have less stress than those who do not.

Finally, students need to enjoy their experiences at optometry college. They need to be involved in both social and service activities. Their classmates are their future colleagues and many are likely to be part of their lives throughout their careers.

References

1. McGinley B, Carlson NB, Hoppe E. What were they thinking? Surveying study practices of entering students. Optometric Education. 2008:33(2):59-63.

2. McGinley B, Carlson NB. Then and now: changes in study practices of first year students. Optometric Education. 2010:35(2):73-76.

3. Hua LV, Goodwin D, Weiss A. Traditional vs. blended learning of pharmacology. Optometric Education. Fall 2013;39(1):28-32.

4. Santiago H. Visual mapping to enhance learning and critical thinking skills. Optometric Education. Summer 2011;36(3):125-139.

5. Heiney EP. Meeting the needs of the optometry student with ADHD. Optometric Education. Fall 2010;36(1):19-23.

6. Bonwell CC, Eison JA. “Active learning: creating excitement in the classroom,” ASHE-Eric Higher Education Report No. 1, George Washington University, Washington, DC, 1991.

7. Freeman S, Eddy SL, McDonough M, Smith MK, Okorafor N, Jordt H, Wenderoth MP. Active learning increases student performance in science, engineering, and mathematics. PNAS: June 10, 2014:Vol 111(23).

8. Prince M. Does active learning work? A review of the research. J Engr Education. 2004;93(3):223-231.

9. Johnson D, Johnson R, Smith K. Active learning: cooperation in the classroom, 2nd Edition. Edina MN: Interaction Book Co, 1998.

10. Johnson D, Johnson R, Smith K. Cooperative learning returns to college: what evidence is there that it works? Change, Vol. 30(4):Jul/Aug 1998,25-35.

11. Heller ML, Marchant GJ. Facilitating self-regulated learning skills and achievement with a strategic content learning approach. Comm Coll J of Reas and Prac. 2015:39(9):808-818.

12. Heys KH, Wawrzynski MR. Male peer educators: effects of participation as peer educators on college men. J Stud Aff Res and Pract. 2013;50(2):189-207.

13. McDaniel K. Read long and prosper: five do’s and don’ts for preparing students for college. Clearing House: a J of Educ Strat, Iss and Ideas. 2014;87(2):83-87.

14. Bonwell CC, Eison JA. 1991. Active learning; creating excitement in the classroom. ASHE-Eric Higher Education Report No. 1. Washington, D.C.: The George Washington University, School of Education and Human Development.

15. UC San Diego School of Medicine. https://meded.ucsd.edu/index.cfm/ugme/oess/study_skills_and_exam_strategies/how_to_study_actively/.

16. Albany College of Pharmacy and Health Sciences. http://peermentors.acphs.edu/blog/acphs-peer-mentors-blog/2014/02/19/how-to-study-actively!

17. Augustin M. How to learn effectively in medical school: test yourself, learn actively, and repeat in intervals. Yale J Biol Med. 2014 Jun;Vol 87(2).

18. Storm BC, Bjork RA, Storm JC. Optimizing retrieval as a learning event: when and why expanding retrieval practice enhances long-term retention. Mem Cognit. 2010;38(2):244-253.

19. Dartmouth Academic Skills Center. http://www.dartmouth.edu/~acskills/success/study.html.

20. Petersen K. http://blogs.einstein.yu.edu/5-ways-to-ace-medical-school-exams-by-maximizing-study-time/.

21. KevinMD.com. http://www.kevinmd.com/blog/2012/07/9-essential-tips-medical-students.html.

22. Markert RJ. What makes a good teacher? Lessons from teaching medical students. Academic Medicine. 2001;76(8):809-810.

23. Brown PC, Roediger HL, McDaniel MA. How to learn better at any age. Boston Globe Magazine. March 9, 2014.

24. MedEdWorld. http://www.mededworld.org/reflections/reflection-items/July-2014/See-one,-do-one,-teach-one-Practice-What-is%28was%29-t.aspx.

25. www.youtube.com. Search for Meditation or Mandala Meditation.

Hyperopia and Presbyopia: A Teaching Case Report

Nancy B. Carlson, OD, FAAO, and Aurora Denial, OD, FAAO | Optometric Education: Volume 41 Number 2

Background

Presbyopia is an age-related refractive condition that results from the normal decrease in amplitude of accommodation necessitating a prescription of plus for near vision.[1] Presbyopia is a common condition in patients over age 40 that most optometrists in practice encounter daily. The techniques for determining the appropriate near prescription for a presbyope are described in many optometric textbooks as well as in the American Optometric Association's *Clinical Practice Guideline on Care of the Patient with Presbyopia*.[2-9] Because optometry students typically practice on each other until they are assigned to clinic, they may fear that examining a presbyope will be very difficult when in fact the examination process is quite straightforward. One of the more difficult parts of the care of the presbyope is tailoring patient management to each individual patient's needs and helping the patient to understand the changes in vision. Patient management can be challenging and takes good listening skills, experience, patience and finesse. While presbyopia is a normal consequence of aging and occurs in everyone sometime after age 40, many patients are surprised by its onset. This case illustrates the process of determining the prescription for the presbyope as well as the importance of giving the patient the empathy, care and support he needs as he begins to need near glasses and continues to see his vision and his correction changing. The case is appropriate for first-year students or for students who are just starting their clinical training. This case can also be used for third- or fourth-year students to review and reinforce the principles and techniques used in caring for presbyopic patients.

Student Discussion Guide

Case description

BD, a restaurant maître d' and personal trainer, presented for an eye exam at age 52 complaining of blur at near both with and without the over-the-counter (OTC) readers he had been using for five or six years. He reported good vision at distance except for some difficulty driving at night. BD had never had an eye exam and he was very concerned that his vision might be deteriorating due to an underlying issue with his health. BD reported his general health as good. He had been taking 10 mg of lisinopril daily for hypertension for 20 years. His blood pressure had last been checked three months before his eye exam. He also reported seasonal allergies, and he was taking Flonase for nasal congestion as needed. He had no allergies to medications. Further personal and family history was unremarkable.

• Visual acuity at distance without correction
OD 20/25
OS 20/80 PH 20/40

• Visual acuity at near without correction
OD 20/80
OS 20/120

• Entrance tests (color vision, cover test, Randot 2, NPC, EOMs, pupils, screening visual fields)
normal

• Retinoscopy
OD +1.50
OS +2.50

• Distance subjective refraction
OD +1.00 20/20
OS +2.00 20/20

• NRA/PRA through a tentative add of +2.00 (tentative add based on the patient's age)
+1.50/-1.50

The distance subjective refraction was trial framed, and BD noted that things looked clear and comfortable at distance looking

not only at the Snellen chart but also down the hall from the clinic and out the window at cars in the parking lot. The add of +2.00 (net near Rx was OD +3.00 and OS +4.00) was trial framed over the distance Rx, and BD found that his vision was much improved from his OTC readers of +2.00. BD's range of clear vision through the trial-framed add was 10" – 20". In the initial case history, BD did not inform the clinician about his OTC glasses. It was not until BD became comfortable with the clinician that he reported that he had been using readers for several years. Because they were not prescribed, he did not think of his readers as "glasses" and he was somewhat embarrassed to admit to using them. BD said, "Oh, these are not glasses, they just magnify things so I can see them."

BD's Goldmann tonometry readings were OD 14 mmHg and OS 14 mmHg at 2:10 p.m. He was dilated with one drop of 1% tropicamide and one drop of 2.5% phenylephrine in each eye. The dilated fundus exam with the binocular indirect ophthalmoscope and 78D lens and slit lamp was normal.

Progressive addition lenses with an Rx of OD +1.00 OS +2.00 Add +2.00 were recommended. BD was also told that although he primarily needed glasses for near work, the prescription given would also be useful for distance, especially for driving at night. He was advised that he could use the glasses for near and still see clearly at distance. As an alternative, he could wear them full-time. For his job as a maître d', wearing the glasses all the time would be most practical. For his job as a personal trainer, he might prefer to put the glasses on only for near tasks. BD was instructed to return for a comprehensive exam in one year.

The patient education for BD included a description of presbyopia as a normal change in vision due to age and that his eye exam did not reveal any evidence of ocular or systemic disease. BD was also told that it was expected that he would need to wear his glasses more frequently as he continued to age and that it was expected that the prescription would need to be changed over time. As he was leaving the clinic, BD expressed his appreciation for the demonstration of his new prescription and for the explanation of presbyopia. He was told to call if he had any questions about his eyes, his vision or his glasses.

About a week after he received his glasses, BD called and said, "You've ruined my life!" He went on to explain that he thought his apartment was clean but now that he had glasses, he could see that it was not and he had a lot to do to clean it up. He said he had thought he was functioning fine with just his OTC readers, and now he was finding himself wearing the progressive addition lenses almost all the time. He found that he liked clear, comfortable vision much more than blurry vision. He again expressed appreciation for his improved vision and said he looked forward to his next exam.

Despite reminders by mail and phone, BD did not return for an examination for three years. He made several appointments over those years but canceled because he was too busy at his two jobs. When he finally made an appointment that he kept, he was very agitated because he could no longer see to read even wearing his glasses. He was again worried that his visual symptoms might mean that he had a terrible disease, perhaps even a brain tumor. BD also reported that he was having a difficult time at his job as a maître d' because he could not see the menus or read the list of specials. He reported that his boss had threatened to fire him if his vision could not be improved.

BD's medical history was unchanged from his previous visit. He was still taking 10 mg of lisinopril daily for high blood pressure. He reported that his last physical exam was one month previous and his doctor found no problems with his health but recommended that he have an eye examination.

• Visual acuity at distance with correction (OD +1.00 OS +2.00, add +2.00)
OD 20/200 PH 20/40
OS 20/60 PH 20/30
OU 20/70

• Visual acuity at near through the add
OD 20/120
OS 20/120
OU 20/120

• Entrance tests (color vision, EOMs, Pupils, screening visual fields)
normal

• Retinosocpy
OD +1.50
OS +2.00

• Distance subjective refraction

OD +3.00 20/20
OS +3.25 20/20

• NRA/PRA through a tentative add of +2.75 over the distance subjective (add chosen based on the patient's near visual acuity through his old glasses)
+1.00/-1.00

The distance subjective refraction was trial framed, and BD noted that things looked clear and comfortable at distance, but he preferred +0.50 less in his left eye. He reported that his vision was much improved from his previous glasses. An add of +2.50 and an add of +2.75 were trial framed over the adjusted distance Rx. BD preferred the add of +2.75. He also reported that the new prescription improved his vision greatly at near compared to his previous Rx. His range of 11" to 18" was adequate for his visual needs. An Rx of OD +3.00 and OS +2.75 with an add of +2.75 was recommended. See **Table 1** for a summary of the refractive data for BD's two examinations.

TABLE 1
Summary of Refractive Findings for BD

	First visit, age 52	Second visit, age 56
Visual acuity	without correction OD 20/25, 20/60 at 16" OS 20/80, 20/120	with correction OD 20/200, 20/120 at 16" OS 20/60, 20/120
Calculated amplitude of accommodation	2.00 D	1.25 D
Subjective refraction	OD +1.00 20/20 OS +2.00 20/20	OD +3.00 20/20 OS +2.75 20/20
Add	+2.00, range 10" – 20"	+2.75, range 11" – 18"
Total new near Rx	OD +3.00 OS +4.00	OD +5.75 OS +5.50
Change in distance Rx from first to second visit		OD +2.00 OS +0.75
Change in near Rx from first to second visit		OD +2.75 OS +1.50

Click to enlarge

Goldmann tonometry was OD 12 mmHg, OS 12 mmHg. The patient was again dilated with one drop of 1.0% tropicamide and one drop of 2.5% phenylephrine in each eye. The dilated fundus exam was normal.

Although BD could see that his vision was improved to 20/20 in each eye at both distance and near, he expressed that he was very concerned with the large change in his vision and his prescription over a period of three years. He asked again if this was due to a disease and was reassured that it was a normal change. He was also advised that he could expect continued changes in his prescription in the years to come. He asked if his vision would change so much that glasses strong enough to correct his vision would not be available. BD was reassured that glasses would be available for him. He was advised to return for a comprehensive examination in one year.

Educational Guidelines

Key concepts

1. Correlation of visual acuity at distance and near to refractive findings

2. Natural history of hyperopia

3. Natural history of presbyopia

4. Testing used to determine a prescription for a hyperopic presbyope

5. The importance of patient education, especially for adults with their first prescription

6. The importance of empathizing with patients about their vision problems

Learning objectives

1. To identify and list the signs and symptoms of hyperopia and presbyopia

2. To be able to correlate symptoms with refractive findings

3. To describe the epidemiology of presbyopia

4. To describe the expected course of changes in hyperopia in adults and in presbyopia

5. To be able to describe the difference between an add and a near prescription

6. To be able to elicit an individual patient's concerns about vision and respond to them appropriately

Discussion questions

A. Knowledge, Concepts, Facts, Information Required for Review of the Case:

1. Describe the signs and symptoms of hyperopia and how it manifests and changes as patients age

2. Describe the signs and symptoms of presbyopia

3. Describe the testing that is done to determine the appropriate prescription for a hyperopic presbyope

4. Describe the natural history of hyperopia

5. Describe the etiology and demographics of presbyopia

6. Describe the impact of a normal age-related reduction in amplitude of accommodation on visual acuity at distance and near for a hyperopic presbyope

7. Discuss the development of refractive amblyopia in anisometropic hyperopes who are uncorrected before the age of 6-8

8. Describe the options for correcting hyperopic presbyopia

9. Discuss the impact of hyperopic presbyopia on a patient's life

10. Discuss the various reactions of patients to the diagnosis and treatment of hyperopic presbyopia, including surprise, anxiety, anger, relief, etc., and how to deal with these reactions

11. Discuss the most common ocular and systemic diseases that should be screened for in the presbyopic population

B. Generating Questions, Hypothesis and Diagnosis:

1. What tests were used to diagnose hyperopic presbyopia?

2. What was the differential diagnosis for the patient's symptoms and how were the other hypotheses ruled out?

C. Management:

1. What are the options for treating hyperopic presbyopia?

2. What is the best option for this patient?

3. How do the patient's jobs influence the recommendations for the best option for this patient and for the recommendations for wearing his prescription?

4. What patient education should be given to all hyperopic presbyopes?

5. Discuss this patient's reaction to his symptoms and how it affects the patient education given and the communication with the patient throughout the examination.

Discussion Points

Before these examination results can be discussed, students should have basic knowledge about presbyopia: definition; epidemiology; etiology; onset and progression; procedures for testing, including methods for determining a tentative add, NRA/PRA, measuring the range and trial framing the prescription; optical options for correcting presbyopia; ocular and systemic health issues prevalent in the presbyopic population; and patient communication with presbyopes. Students may learn this information through lectures, readings, online resources or a combination of these learning methods. In addition, students should have a lab and practice the techniques used for determining a presbyopic prescription. If the students are testing each

other in lab, the student serving as a patient can be cyclopleged with 1% tropicamide to simulate presbyopia.

Students can be given cases to review, such as those in Kurtz's chapter in Brookman (1994),[10] Ettinger and Rouse (1997)[11] and Werner and Press (2002).[4] Although these cases will be somewhat similar to the case presented here, repetition is a tried and true learning method that helps students to master material.

A faculty member, teaching assistant or student can lead a discussion of this case either in a large classroom setting or in a small group. Students should be given all of the history, clinical data and patient education from both visits to review before the case discussion. Students should be encouraged to write questions they have about the case along with a list of topics they would like to discuss.

The discussion can start with an analysis of the patient history. Given BD's age and complaints, what do they expect to find during the examination? Because BD never had an eye examination before age 52, he is likely to be emmetropic or hyperopic. It is also likely that he has been presbyopic for several years. The epidemiology, etiology, onset and progression of presbyopia can also be discussed when analyzing the case history. When would BD have been first expected to have symptoms of presbyopia? How did he manage to be 52 before needing an eye exam? Is this common? Were his OTC glasses of +2.00 that he wore since approximately age 46 a large add for that age? How did his refractive error contribute to the prescription of plus that he needed for near? Review the difference between a near prescription and an add with the students. For BD, +2.00 OTC readers were most likely a partial correction of his hyperopia with an add. Patients in their 40s usually need a first add of +0.75 or +1.00, so BD's glasses of +2.00 were likely to be +1.00 or +1.25 to correct hyperopia with an add of +1.00 or +0.75. When a patient is wearing +2.00 for near in his 40s, hyperopia is the expected refractive error.

Symptoms of presbyopia generally first occur in patients age 40 to 45.[12] Many patients cope with the symptoms of blur at near by increasing light or moving reading material further away to decrease the demand on their accommodation. Often patients will resort to OTC plus lenses as a solution to their problem. As the amplitude of accommodation continues to decrease and patients notice the solutions are no longer working, they finally have an eye exam. Although optometrists are expecting to find presbyopia in their patients after age 40, Walline, Zadnik and Mutti[13] (1996) found that more than half of the patients surveyed did not know the definition of presbyopia or how it would affect them in their activities of daily living.

BD did not reveal he was using OTC reading glasses until after the refraction. He was somewhat embarrassed by this. Discuss the patient's perception that OTC readers are not "real glasses." Is this a common perception? Would it be possible to elicit this information earlier in the exam or during the case history? Perhaps a question such as "What do you do when you are having trouble with close work to make it easier to see? Do you use more light, hold things further away or use glasses from the drugstore?" would help the patient to realize that some of the attempted solutions are not unusual.

Patient communication is obviously important in every patient encounter and, as Ettinger (1994) says, is "the core of good clinical care."[14] Students need to learn to make the patient the most important person in the room during the exam. They also need to develop good listening skills and empathy to let the patient fully express his or her concerns. In this case, BD had an extroverted personality and was fairly comfortable talking with the clinicians. He did, however, show anxiety about his "deteriorating vision" at both exams. Although presbyopia is inevitable, most patients do not know that fact and many are surprised and upset by the symptoms of presbyopia and what they mean.[12] Discuss how to alleviate the patient's concerns. What tests were done as part of this exam to rule out health problems as a cause for the patient's symptoms? What else could have been said as part of the patient education that might have helped BD? Discuss the use of written materials for patients that explain common eye conditions.

Lloyd and Bor (2004)[15] report that the goals of patient education include helping patients understand their conditions, reducing their anxiety and enlisting their cooperation in the management of the problem. BD's follow-up call the week after he received his glasses seemed to demonstrate that he understood the problem at that time and could even laugh about it. Despite that, he had developed a lot of anxiety by the time of his second appointment three years later. Some of his anxiety was no doubt due to his hectic work schedule. At his second visit, he was obviously very relieved when he saw his vision improved to 20/20 at both distance and near with a change in prescription.

Is there anything in the initial case history that points to the possibility of an ocular or systemic health problem? What are the common health issues that should be screened for in a 52-year-old patient? Cataracts, glaucoma, high blood pressure and diabetes are most common in this age group and are screened for in every adult examination. Macular edema, thyroid abnormalities and orbital masses can cause refractive changes and should be considered when there are changes in visual acuity, color vision or refractive error.[9,16] For BD, specific discussion of what testing was done and how it ruled out ocular and systemic disease would help to reassure him about his health. Werner and Werner[17] (1979) emphasize the importance of showing sensitivity to the entire patient and not just his or her eyes. Many patients view presbyopia as another sign of aging,

but don't know that the amplitude of accommodation diminishes for many years before reading glasses are needed. It is often helpful to let patients know this.

Review the exam data. Is the uncorrected visual acuity at distance and near correlated with the subjective refraction and add findings? Based on the patient's age, what add is expected? How does the distance refraction affect the add?

The hyperopic patient's distance visual acuity without correction is related to the amount of hyperopia and the patient's amplitude of accommodation. Patients are usually comfortable if they are using no more than half of their accommodation. During visual acuity measurement, a patient is able to use all of his accommodation to read a line of letters because it only takes a few seconds. In this case, BD at age 52 would be expected to have an amplitude of accommodation of 2.0 D according to Hofstetter's formula: Amplitude of Accommodation = 15 – 0.25 X age. At his first visit, his distance uncorrected visual acuity was 20/25 in the right eye and 20/120 in the left eye. The subjective refraction showed +1.00 in the right eye and +2.00 in the left eye. Uncorrected distance visual acuity in hyperopes is not always as predictive of the refractive error as it is in myopes.

The initial refraction revealed a difference in hyperopia between the two eyes. Refractive amblyopia is not a concern for this patient since BD's vision is correctable to 20/20 in each eye and he is well past the age of 6 to 8 when the development of amblyopia is a concern.[18] However, if his vision was decreased in the eye with the higher hyperopia amblyopia versus pathology would have to be investigated.

The natural history of hyperopia is that it becomes more manifest as the patient ages, and the ability to compensate for it decreases with the normal decrease in amplitude of accommodation.[19-21] Because BD had his first eye exam at age 52, there is no previous data to show how hyperopic he was at an earlier age. With many patients, the full amount of hyperopia is not known unless the patient has been cyclopleged or until the patient is presbyopic. Cycloplegic refraction is not indicated in a patient with an expected amplitude of accommodation of 2.0 D.

Discuss the options for correcting presbyopia. Why were progressive addition lenses recommended for BD? Does he need to wear them full-time? Is he likely to wear them full-time at this point? Given that his distance vision without correction was 20/25 at his first visit, it is unlikely that he will start wearing progressive addition lenses full-time. Because he has managed to function with OTC readers for several years, he will be quite likely to use his PALs in the same manner. Discuss how his jobs will determine his visual needs and his use of glasses. Many presbyopes wear contact lenses, which can be considered in the future for BD.

The assessment of the learning objectives can occur in several ways. In a clinical exam setting, the psychomotor skills could be tested. Students could be tested on refraction, near add determination, correlation of symptoms to refractive error and determination of the final near prescription for a presbyopic patient or a patient who has a simulated presbyopia. Assessing students' knowledge about symptoms, epidemiology and expected changes could be accomplished using role playing. This would also be helpful in evaluating a student's ability to elicit and address a patient's concerns about changes in vision.

Conclusion

BD's case of hyperopic presbyopia is similar to many cases that students will see in their careers as optometrists. Early in their training, the testing process and the decision on prescribing seems somewhat mysterious to students, partly because it is so beyond their own visual experience. BD's case is more interesting than a routine case of presbyopia because of his reaction to his symptoms, both at his first and second visit. Every patient needs the full attention of his clinician to his concerns, and students need guidance in learning how to establish an atmosphere in which patients feel comfortable expressing their problems. Case discussions like this, along with experience in clinical patient care, will help students to become competent clinicians.

References

1. Millodot M. Dictionary of Optometry and Visual Science, Sixth Edition. Boston: Butterworth-Heinemann, 2004, 249.

2. Carlson N, Kurtz D. Clinical Procedures for Ocular Examination, 3rd Edition. New York: McGraw-Hill, 2004, 146-150.

3. Zadnik K. The Ocular Examination, Measurements and Findings. Philadelphia: WB Saunders Company, 1997, 115-117.

4. Werner DL, Press LJ. Clinical Pearls in Refractive Care. Boston: Butterworth-Heinemann, 2002, 139 – 178.

5. Rosenfeld M. "Chapter 15, Clinical Assessment of Accommodation" in Rosenfeld M and Logan N (eds), Optometry, Science, Techniques and Clinical Management, Second Edition. Edinburgh: Elsevier, 2009, 237-239.

6. Newman JM. “Chapter 21, Analysis, Interpretation and Prescription for the Ametropias and Heterophorias” in Benjamin WJ (ed), Borish’s Clinical Refraction. Philadelphia: WB Saunders Company, 1998, 803-806.

7. Fannin TE. “Chapter 21, Presbyopic Addition” in Eskridge JB, Amos J, Bartlett JD. Clinical Procedures in Optometry. Philadelphia: JB Lippincott Company, 1991, 198-205.

8. Grosvenor T. Primary Care Optometry, Fifth Edition. St. Louis, MO: Butterworth Heinemann Elsevier, 2007, 254-256.

9. American Optometric Association Clinical Practice Guideline on Care of the Patient with Presbyopia. St. Louis: AOA. Revised, 2010.

10. Kurtz D. Chapter 7, Presbyopia. Refractive Management of Ametropia. K Brookman, Editor. Boston: Butterworth, 1996.

11. Ettinger ER, Rouse MW. Clinical Decision Making in Optometry. Boston: Butterworth-Heinemann, 1997.

12. Kleinstein RN. Epidemiology of Presbyopia. In Stark L, Obrecht G, eds. Presbyopia: Recent Research and Reviews from the Third International Symposium. New York: Professional Press Books, 1987:12-28.

13. Walline JJ, Zadnik K, Mutti DO. Validity of surveys reporting myopia, astigmatism, and presbyopia. Optom Vis Sci. 1996;73:376-81.

14. Ettinger ER. Professional Communications in Eye Care. Boston: Butterworth-Heinemann, 1994.

15. Lloyd M, Bor R. Communication Skills for Medicine, Second Edition. Edinburgh: Churchill Livingstone, 2004.

16. Moore BD, Ciner EB, Augsberger AR, et al. American Optometric Association Clinical Practice Guideline on Care of the Patient with Hyperopia. St. Louis: AOA. Revised, 2008.

17. Werner DL, Werner W. Presbyopia and mid-life transition. Rev Optom. 1979:July;43.

18. Rouse M, Cooper J, Cotter S, et al. American Optometric Association Clinical Practice Guideline on Care of the Patient with Amblyopia. St. Louis: AOA, 1994.

19. Moore B, Lyons SA, Walline JJ. A clinical review of hyperopia in young children. JAOA. 1998;69(2):88-114.

20. Grosvenor T. Changes in Spherical Refraction During the Adult Years. In Grosvenor T, Flom M, eds. Refraction Anomalies, Research and Clinical Applications. Boston: Butterworth-Heinemann, 1991:131-45

21. Lee KE, Klein BE, Klein R, Wong TY. Changes in refraction over 10 years in an adult population: the Beaver Dam Eye Study. Invest Ophthal Vis Sci. 2002;43:2566-71.

Long-term Follow-up of Suspected Vaccine-Induced Papillitis: A Teaching Case Report

Brianne Hobbs, OD, FAAO, and Kaila Osmotherly, OD, FAAO | Optometric Education: Volume 41 Number 2

Background

Optic neuritis results when the optic nerve becomes inflamed. Two major clinical presentations of optic neuritis exist: typical demyelinating and atypical. Typical demyelinating optic neuritis is the most common presentation and includes the following features: acute monocular vision loss (which typically improves after two weeks), pain on eye movement, visual field defect and relative afferent pupillary defect (RAPD) on the affected side.[1] Demyelination in typical optic neuritis may be idiopathic or induced by a systemic demyelinating disorder. Atypical optic neuritis is characterized by the following features: occurrence in a patient under age 14 or over age 45, bilateral presentation, vertical hemianopic visual field defect, recent sinusitis and/or progression of the optic neuritis for more than two weeks.[1] Atypical optic neuritis is more concerning than typical demyelinating optic neuritis and indicates the need to perform additional testing for systemic conditions.

Optic neuritis is also classified into two principal types according to what portion of the optic nerve is involved.[1-3] Papillitis, also known as anterior optic neuritis, occurs when the intraocular portion of the optic nerve is inflamed. Retrobulbar optic neuritis affects the segment of the optic nerve posterior to the globe.[1-3] Papillitis is more common in children than adults.[1-3]

The etiologies of optic neuritis may be classified into four categories: demyelinating, infectious, non-infectious and parainfectious.[2] The axons of the retinal ganglion cells become myelinated after passing through the lamina cribosa, and demyelination occurs when the myelin is phagocytosed by the microglia and macrophages, thus interrupting axonal conduction.[2] Demyelinating optic neuritis may be the first sign of multiple sclerosis (MS). Neuromyelitis optica, another systemic demyelinating disease, is characterized by bilateral optic neuritis in addition to demyelination of the spinal cord. Infectious etiologies of optic neuritis include, but are not limited to, sinusitis, cat-scratch fever, syphilis and Lyme disease.[2] Non-infectious causes of optic neuritis include sarcoid, systemic lupus erythematosus and polyarteritis nodosa.[3] Parainfectious causes of optic neuritis include immunizations and viral infections such as chickenpox, measles and rubella.[2] Despite reduced visual acuity in the acute phase, most patients regain their prior visual acuity, even without treatment. Long-term complications of optic neuritis may include optic nerve atrophy, reduced visual acuity, decreased contrast sensitivity and reduced color vision.[3]

This case report focuses on the etiology, clinical presentation and prognosis of optic neuritis in the pediatric population and specifically investigates a rare cause of papillitis — vaccines. This report also addresses the potential long-term sequelae of papillitis in children. This teaching case report would be appropriate for third- and fourth-year optometry students as well as optometric residents.

Case Description

Initial presentation to outside provider in 2004 (records were obtained with patient's permission)

TABLE 1
Serology Testing at Hospital

	Result
	Mildly elevated WBC count Mildly depressed lymphocyte count Elevated segmented neutrophils
	18 mm/hr (range 0-15)
	Negative
	Negative
s Disease	Negative
rmone	< 0.1 uIU/mL (range 0.4-6.0)

Click to enlarge

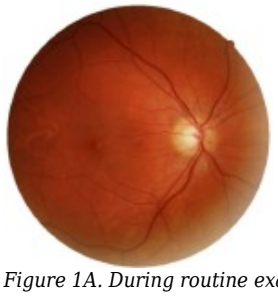


Figure 1A. During routine examination, C/D ratio in the right eye was noted to be .7/.7.
Click to enlarge

Figure 1B. During routine examination, C/D ratio in the left eye was noted to be .65/.65.
Click to enlarge

A healthy 12-year-old patient presented with a complaint of vision loss in his right eye upon awakening. Specifically he noticed that a portion of his face was obscured by blur when he looked in the mirror and that “everything had a red hue to it.” Associated symptoms included mild pain upon eye movement. He had noticed a headache, which was relieved with Tylenol, two days prior to the onset of vision loss. Visual acuity was 20/400 OD and 20/20 OS. His ocular history was notable for myopia. The patient was of normal weight; his medical history was remarkable for motion sickness. He had received vaccinations for hepatitis B and tetanus approximately four weeks earlier. Family history was positive for thyroid disease. Pupil evaluation revealed a 3+ RAPD in the right eye in association with a visual scotoma on visual field testing in the same eye; the left eye showed no visual field defect. A dilated fundus exam revealed optic nerves judged to be .2/.2 right eye and .3/.3 left eye with no apparent edema or pallor. The patient was referred to the emergency department for additional evaluation.

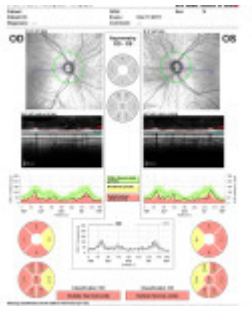
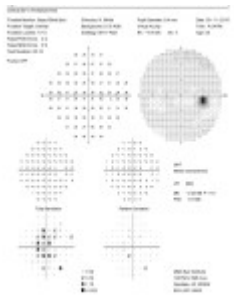
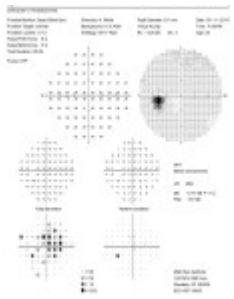


Figure 2. OCT showed retinal nerve fiber layer thinning in all quadrants and optic nerve atrophy.
Click to enlarge



Figures 3A and 3B. Threshold visual field testing showed minimal diffuse loss on the mean deviation and no diffuse loss on the pattern deviation, indicating that the patient did not have functional vision loss.
Click to enlarge



Click to enlarge

A head CT without contrast was obtained and the results were interpreted as normal. A T1/T2 weighted MRI of the brain, orbits, face and neck with and without contrast and fat saturation were obtained later that day, but no abnormalities were evident.

The patient was diagnosed with a complicated migraine following this visit. The assessment note stated: “The patient’s history and findings are most consistent with that of a migraine headache with a neurologic deficit related to the retina and/or optic nerve.” The patient was subsequently discharged and no treatment was prescribed.

Five days later, the patient was admitted to the hospital due to acute vision loss in his left eye. The patient noted slight pain on eye movement at this time in addition to the vision loss now present in both eyes. His visual acuity was finger counting OD and 20/400 OS. A 2+ RAPD OD was noted. Extraocular motility was full, but visual fields showed restriction in the superior field of the right eye with a full confrontation visual field in the left eye. The patient was dilated in the hospital and both nerves showed evidence of mild swelling in the absence of hemorrhages or exudates. Serology was obtained **(Table 1)**. The diagnosis of bilateral optic neuritis secondary to hepatitis B vaccination was made at this time, and the patient began intravenous methylprednisolone 250 mg every six hours for three days. His vision gradually returned and was considered normal 12 days after he experienced his initial symptoms.

Present-day examination (2014)

The patient presented to the Midwestern University Eye Institute for a routine eye examination. He reported a history of optic neuritis secondary to hepatitis vaccination when he was 12. His ocular history was otherwise unremarkable. His corrected

visual acuities were 20/15 OD, OS, and all other entrance testing was normal. No afferent pupillary defect was noted. Red cap testing was equivalent in each eye. Color vision was normal OD, OS with both D-15 and desaturated D-15 color tests. Contrast sensitivity testing was performed using the Pelli-Robson contrast sensitivity test and was assessed at 1.95 OD, OS. Intraocular pressures were 17 mmHg OD, OS. Upon dilation, his optic nerves appeared to have mild diffuse pallor and were suspicious for excavation. The C/D ratio was judged as .7/.7 OD, .65/.65 OS **(Figures 1A and 1B)**. Retinal nerve fiber layer (RNFL) thinning was present in all quadrants on OCT **(Figure 2)**. Threshold visual field testing **(Figures 3A and 3B)** revealed non-specific diffuse loss.

Education Guidelines

Discussion points

1. What is the pathophysiology of optic neuropathy?
2. What are the two major anatomic classifications of optic neuritis?
3. What is the most common type of optic neuritis in adults?
4. What is the importance of myelin in axonal conduction relative to optic neuritis?
5. What are the characteristics of atypical optic neuritis?
6. What are causes of compressive optic neuropathy?
7. What are the differentials for acute unilateral vision loss in children?
8. What laboratory tests would be appropriate for a child presenting with a swollen optic nerve?
9. What are the differentials for optic nerve pallor in a young adult?
10. How do the two major presentations of optic neuritis differ anatomically?
11. What symptoms are most common in adults presenting with optic neuritis?
12. What symptoms are most common in children?
13. What are the most common causes of optic neuritis in an adult population?
14. What are the most common causes in a pediatric population?
15. What clinical tests can be utilized to confirm the diagnosis of optic neuritis?
16. What are appropriate treatment options for optic neuritis?
17. Are there any trials that provide strong evidence for specific treatments?
18. What were the inclusion criteria in these studies?
19. What are the long-term consequences of optic neuritis?
20. Can these consequences be prevented?

Learning objectives

1. Define optic neuropathy and list the major categories of optic neuropathy
2. Review the major causes of optic neuritis

    a. demyelinating
    b. infectious
    c. non-infectious
    d. parainfectious

3. Understand the anatomical variants of optic neuritis and review the four anatomical divisions of the optic nerve as it travels to the brain

    a. retrobulbar vs. papillitis
    b. intraocular
    c. intraorbital
    d. intracanalicular
    e. intracranial

4. Recognize the characteristics that make an optic neuritis atypical

    a. understand the implications of atypical optic neuritis

5. Discuss the most common symptoms associated with optic neuritis

6. Discuss the most common signs associated with optic neuritis

a. identify clinical tests that aid in the diagnosis of optic neuritis

7. Identify the signs and symptoms necessary to make a clinical diagnosis of optic neuropathy

a. presentation
b. course of the illness

8. Identify the differences in optic neuritis presenting in adults and children in regard to the following

a. symptoms
b. ocular signs
c. associated conditions/etiology
d. natural history/prognosis

9. Understand the proper treatment for optic neuritis and when treatment should be utilized

10. Identify the long-term complications of optic neuritis

11. Develop the knowledge to counsel patients on the likely outcome of optic neuritis

Key concepts

1. Visual acuity is not the most sensitive measure of visual function in patients with optic neuritis; therefore, additional characteristics such as contrast sensitivity should be assessed.
2. The optic nerve head is more likely to be swollen in pediatric optic neuritis than in adult optic neuritis, and the presentation is often bilateral in children.
3. The most common etiology of pediatric papillitis is a preceding viral illness (parainfectious).
4. Optic neuritis has a favorable prognosis for complete visual recovery in children and is less likely to be predictive of MS than optic neuritis occurring in adults.
5. A patient with a history of pediatric optic neuritis should be followed for the development of optic atrophy and can be monitored with visual field testing and OCT.
6. Although most patients exhibit some degree of optic atrophy following optic neuritis, visual acuity is not always reduced.

Discussion

Differential diagnosis for optic neuropathies in children pertinent to this patient's history

1. Complicated migraine

The diagnosis of complicated migraine was the patient's initial diagnosis, which was made in the ER. This diagnosis was likely made based on the patient's symptoms and normal imaging. The treating physician may have been referring to a retinal migraine or an ophthalmoplegic migraine. Retinal migraines can present with unilateral vision loss and visual field defects; the vision loss is typically transient (lasting less than one hour) and either precedes or presents concurrently with the headache.[4] This diagnosis is inconsistent with the patient's presentation as his headache preceded visual symptoms by two days. Retinal migraines are considered to be a diagnosis of exclusion,[5] and at the initial presentation not all differentials had been ruled out. The term "complicated migraine" was historically used to describe an ophthalmoplegic migraine (a headache associated with oculomotor nerve palsies).[5] This patient did present with an RAPD of the right eye, but did not demonstrate any other oculomotor deficit. Although this was the initial diagnosis made by the ER physician, given the patient's presentation, it was not the most appropriate diagnosis.

2. Compressive optic neuropathy

Compressive optic neuropathy is due to a mechanical force acting on the nerve caused by a space-occupying lesion or enlarged extraocular muscles secondary to thyroid eye disease. This patient did not have thyroid eye disease evidenced by ocular examination and serological testing. He did have a strong family history of thyroid dysfunction, but he had never been diagnosed and the likelihood that his thyroid dysfunction could be advanced enough to cause compressive optic neuropathy yet evade detection is minimal. Neuro-imaging ruled out space-occupying lesions such as neuroblastomas and optic nerve gliomas.

3. Hereditary optic neuropathy

Leber hereditary optic neuropathy occurs due to mitochondrial DNA mutations. It often presents in the first or second decade of life, and is an important differential to rule out in a patient with bilateral optic neuritis. Typically there is disc hyperemia with blurred margins, and there may be dilated capillaries on the disc.[2] The patient underwent genetic screening for Leber hereditary optic neuropathy, and his screening test was negative.

4. Optic neuritis

Pediatric optic neuritis is not a common condition; its incidence is less than 0.00005% annually.[6-8] It is, however, an important condition to recognize and properly manage. Potentially life-threatening etiologies such as space-occupying lesions must be excluded initially with the use of neuro-imaging. A lumbar puncture with cerebrospinal fluid analysis can identify other serious etiologies of a swollen nerve, such as meningitis. This patient's clinical findings of asymmetrically reduced visual acuity, an afferent pupillary defect, and the absence of a space-occupying intracranial lesion were indicative of bilateral papillitis.[9] After excluding life-threatening diagnoses, the major categories of papillitis should be investigated: demyelinating, infectious, non-infectious and parainfectious.

a. Demyelinating

Demyelination may occur to the optic nerve sheath alone (isolated optic neuritis), or it may be a widespread, systemic phenomenon. Characteristic MRI findings of optic neuritis include foci of T2 bright signal, areas of enhancement within/surrounding the optic nerve, and possible optic nerve enlargement.[3] Contrast-enhanced T1-weighted MR images have a high sensitivity for detecting acute optic neuritis and typically show enhancement of the inflamed portion of the optic nerve.[3] Demyelinating optic neuritis neuro-imaging findings may be enhanced by the fluid-attenuated inversion recovery (FLAIR) pulse sequence. Optic neuritis may be the presenting sign of systemic disorders such as MS, acute disseminated encephalomyelitis (ADEM), or neuromyelitis optica (NMO). Although the AQP-4 serology test to rule out NMO was still in development at the time of the initial presentation of the patient in this case report, the patient had no systemic symptoms of spinal cord demyelination, which is necessary in the diagnosis of NMO. These disorders were ruled out by the aforementioned neuro-imaging; more advanced imaging of the spinal cord was likely not obtained due to the patient's normal gait, unaffected motor coordination, and lack of other neurologic deficits. Despite the normal neuro-imaging, the patient may still be at heightened risk for future development of demyelinating disorders. The evidence is inconclusive regarding the long-term risk of such conditions following pediatric optic neuritis.[10]

b. Infectious

Bartonella henselae, the gram-negative bacillus responsible for cat-scratch disease, is capable of causing neuroretinitis in children more often than adults. Neuroretinitis is characterized by a swollen optic nerve and retinal exudates.[9] According to the patient's records, no exudates or hemorrhages were noted within the retina, thus greatly reducing the likelihood of neuroretinitis. Sinus-related optic neuritis is another cause of infectious optic neuritis, but is usually associated with a severe headache and spheno-ethmoidal sinusitis; our patient had neither of these findings.[2] Syphilis may cause a unilateral or bilateral optic neuritis, but our patient was healthy and had no history of exposure to syphilis.[2] Lyme disease, caused by the spirochete *Borrelia burgdorferi*, may cause optic nerve swelling. This patient had no history of a tick bite and his Lyme titer was negative.

c. Non-infectious

Papillitis or retrobulbar optic neuritis may occur in patients with sarcoid if the optic nerve is affected by granulomatous inflammation.[3] Pain is often absent in this type of optic neuritis and a mild vitritis may be present.[3] Sarcoid was not a likely differential in our patient due to his age and health history. Optic neuritis may also be present in patients with vasculitis such as systemic lupus erythematosus and polyarteritis nodosa. An antinuclear antibody screen was negative, making it highly unlikely that this patient's optic neuritis was the result of a systemic vasculitis.

d. Parainfectious

Many viral illnesses such as measles, mumps, infectious mononucleosis, pertussis and chicken pox may result in a subsequent optic neuritis. Vaccinations may also cause optic neuritis by initiating an immune response that may ultimately target the optic nerve. This patient was diagnosed with optic neuritis secondary to vaccinations, a parainfectious cause of optic neuritis. The patient had no other predisposing factors to optic neuritis other than the

possible association with the hepatitis B or tetanus vaccine he had received four weeks earlier. It is also plausible that the patient's optic neuritis was idiopathic, rather than induced by the vaccine, because temporal association does not always indicate causation.

Differential diagnosis for optic atrophy pertinent to present-day examination

When the patient was first examined at the Eye Institute in 2014, he was asymptomatic, but objective measures such as the dilated fundus examination and OCT revealed optic atrophy. His optic atrophy was secondary to his history of optic neuritis as child, but if his history had been unremarkable, the potential list of differentials would be relatively brief. Given his age, primary open-angle glaucoma or congenital glaucoma would be extremely rare. There were no signs of secondary glaucoma. A hereditary optic atrophy would fit with the patient's optic nerve appearance, but it is not consistent with the patient's excellent visual function and lack of symptoms.

Clinical tests

When a pediatric patient presents acutely with a swollen optic nerve head and decreased vision, an MRI and lumbar puncture are necessary in order to exclude the most prognostically detrimental conditions. The MRI can detect conditions such as optic nerve gliomas, hydrocephalus and other space-occupying lesions. The lumbar puncture is important for identifying elevated intracranial pressure, and it can also aid in the diagnosis of meningitis, encephalitis and leukemia.

This patient's 2014 exam was more than a decade after his optic neuritis had resolved, and the most ominous threat to vision was the development of optic atrophy. The patient presented to the clinic long after any treatable condition had subsided, and he did receive the most appropriate treatment at the time of his acute optic neuritis. The patient's visual acuity was 20/15 OD, OS which indicated that the optic atrophy, though anatomically detectable, had not yet affected visual function to a large degree. In patients with a history of optic neuritis, it has been well-documented that although acuity returns to original levels, contrast sensitivity is impaired. In this patient, contrast sensitivity (1.95) was found to be normal according to the Pelli-Robson test. No relative afferent pupillary defect, a finding that would be present in both acute optic neuritis and asymmetric optic atrophy, was noted. A red cap test revealed no significant difference between the two eyes, an expected finding because the optic neuritis was largely symmetrical. Color vision was normal in both eyes. Upon dilated examination, the optic nerves did appear atrophic **(Figures 1A and 1B)**. The optic nerve atrophy was also seen on OCT, which did indicate RNFL loss in both eyes **(Figure 2)**. A Humphrey visual field test was performed to examine the correlation. It showed minimal diffuse loss on the mean deviation and no diffuse loss on the pattern deviation, demonstrating that the patient did not have functional vision loss **(Figures 3A and 3B)**.

Clinical decision-making

Decision-making in this case centered on four major questions.

1. How did the patient's history relate to the exam findings?

a. This patient presented with a history of one episode of optic neuritis 10 years prior. It was important to incorporate this known history with the ocular signs present during the exam, such as RNFL thinning and optic atrophy visible funduscopically. Normally, any type of RNFL thinning would be unexpected in a 23-year-old and an immediate cause of concern, but in this situation the cause was evident from the history. Discovering the likely etiology of this episode was important in determining the patient's prognosis. For example, if the optic neuritis was secondary to a viral illness, the long-term prognosis is excellent without any intervention. If the neuropathy was associated with toxicity or malnutrition, the prognosis is less favorable.

i. An appropriate question is why the neuro-imaging was normal if the patient was diagnosed with optic neuritis. The imaging was ordered by an emergency department physician with no note of the slice thickness. It is possible the slices were too thick to observe inflammation if optic neuritis was not specifically considered in the emergency department. The imaging report specifically refers to ruling out the presence of a mass, so the focus of imaging may have been on too large a scale for this patient. This demonstrates the need for the optometric physician to continue to be involved in the imaging process.

b. The OCT **(Figure 2)** indicated pronounced thinning in all quadrants in both eyes. While this is unsettling, the anatomical changes have not yet manifested as functional visual field loss. This OCT is consistent with the expected findings for a patient with a history of bilateral optic neuritis.[11] Due to technological advances such as OCT, subtle anatomical structural changes are detectable before visual function declines.[12] This phenomenon explains why the OCT indicates thinning, but the visual field remains relatively normal with excellent visual acuity. It is also possible that the

optic nerve is more resilient in childhood when this patient's papillitis occurred, so the damage was milder than expected. Multiple studies have found that visual acuity and visual fields remain unaffected until pronounced thinning of the RNFL occurs.[13-14] Contrast sensitivity testing is considered a more sensitive method than traditional Snellen visual acuity measurement for detecting small declines in visual function.[15] A small study of RNFL thickness in patients with a history of optic neuritis found that for every line of decrease of contrast sensitivity, the mean RNFL thickness decreased by four microns.[16]

2. Are any threats to vision present?

a. The damage from the prior episode of optic neuritis was irreversible, but the patient should be carefully examined for any additional conditions that may pose a threat to vision. Initially the C/D ratio was judged as .2 OD/.3 OS without edema or pallor, but in the eyecare clinic, the nerves were assessed as .7 OD/.65 OS. Perhaps the difference between these two ratios was inter-observer variance, but it could also indicate that the nerve was swollen initially but it was missed because of the physiologically large C/D. Alternatively, RNFL rim thinning could have resulted from the initial presentation, but this is doubtful due to the largely intact visual field. When carefully examining the optic discs for edema, such as in this patient, it is important to assess the size of the optic nerve head. If the disc itself is small, the axons are crowded into a smaller space, mimicking edema. If the disc is large, the axons have a greater area to occupy, which could make the rim tissue appear thinned when it is not. This patient had true pallor secondary to his prior papillitis (evidenced by the OCT), but measuring the optic nerve head is a valuable exercise clinically because it gives a broader perspective on the health of the optic nerve. A recurrence of optic neuritis could certainly be considered a threat to vision due to its long-term effects on the optic nerve, but in this case recurrence is unlikely. It cannot be ruled out that the appearance of the optic nerve was due to some other pathological process, but this scenario is unlikely as Ockham's razor proposes that the simplest explanation is often the most likely. Glaucoma could result in damage to the RNFL similar to that seen in this patient, but the likelihood of a healthy 23-year-old developing glaucoma with no other predisposing factors is very low. The most predictive signs of non-glaucomatous cupping are patient age less than 50 years and optic disc pallor in excess of cupping, which were consistent with the patient's presentation.[17,18] Other than continued RNFL loss with subsequent effects on the rim tissue of the optic nerve, no other threats to vision persist long-term in this patient.

3. Is there any treatable condition at this time?

a. The adage "treat the treatable" is applicable in this scenario. Optic atrophy is not treatable once the inciting agent has been removed. The argument could be made that this patient is more susceptible to any factor that might further damage the optic nerve, such as increased IOP, because the optic nerve is already compromised. It could be argued that treatment with ocular hypotensives should be initiated to protect the remaining RNFL, but the mechanism of damage has already been eliminated so there is no active process to treat. Treating a young, healthy, asymptomatic patient with mild optic atrophy with topical hypotensives for the rest of his life is an aggressive strategy that may provide no benefit to the patient. The patient's IOP in the office was 17 mmHg OU. The benefits of lowering these normal pressures further is of questionable benefit. Pachymetry was not performed, but if this patient had thin corneas it could provide additional evidence to treat as thin corneas have been shown to be an independent risk factor for the development of glaucoma per the Ocular Hypertension Treatment Study.[19]

4. How should the patient be managed moving forward?

a. This patient is at a higher risk of developing MS due to his history of optic neuritis. He only had a single occurrence of optic neuritis, which followed the typical course, so his risk is likely lower than a patient who had suffered multiple bouts of optic neuritis. The patient would also likely have a higher risk for developing NMO if he had experienced multiple episodes of optic neuritis. NMO may cause an atypical optic neuritis that tends to affect contrast sensitivity more severely and result in greater thinning of the RNFL than a typical demyelinating optic neuritis.[19]

b. As there is no condition to actively treat, the emphasis should be on patient education and appropriate follow-up. Close inspection of the optic nerve is important to potentially detect any additional pathology unrelated to the papillitis that may develop. It could be argued that annual exams are the only necessary follow-up. It is also reasonable to advocate performing a visual field test, RNFL OCT, and stereoscopic fundus photography annually to more carefully monitor the patient for the development of any co-morbidities (such as glaucoma development) that may require more aggressive treatment relative to a patient with no optic nerve damage.

Literature review

Vaccine-induced optic neuritis is not a common entity, and its existence may even be questionable as often there is only a correlation between the administration of a vaccine and optic neuritis rather than a proven causation. To establish causality,

ideally there should be a dose-response association, reports of adverse effects at multiple locations, or a proposed biological mechanism by which the reaction could occur, in addition to a temporal association.[20] Reports of vaccine-induced optic neuritis usually include a presentation from days to four weeks following vaccination although there are some reports of optic neuritis up to six months following the influenza vaccine.[3,20-22] The most common vaccine associations with optic neuritis are with the hepatitis B vaccine and the influenza vaccine.[22] The first report of a demyelinating disorder associated with the hepatitis B vaccine was in 1983, at which time the hepatitis B vaccine was plasma-derived. The production of the hepatitis B vaccine was altered in 1987 when the recombinant form of the vaccine became available, and this is the vaccine type the patient in this case would have received. Recombinant vaccines are produced by inserting genes for a specific antigen into a suitable vector, which is commonly a virus with a low virulence. The benefit to a recombinant vaccine is the low risk of adverse events. Hepatitis B is currently the only recombinant vaccine widely available. The use of adjuvants could also be the mechanism by which vaccines generate immune-related disorders, but one of the most implicated adjuvants, thimerosal, has now been effectively eliminated from childhood vaccines as the maximum allowable concentration is 0.00002% .[23]

Although the evidence is far from conclusive, it is possible that if optic neuritis is indeed an uncommon adverse effect associated with vaccines, it likely only occurs in genetically susceptible individuals. Specifically HLA-DRB1 and HLA-DQB1 have been implicated in these cases.[21] One large study conducted by Payne et al. refuted the association of several vaccines with optic neuritis. This matched case-control study involving 1,131 cases of optic neuritis found no statistically significant difference between optic neuritis and the following vaccines: anthrax, smallpox, hepatitis B or influenza.[21]

Pathophysiology

The optic nerve is divided into four anatomical sections as it travels posteriorly: intraocular, intraorbital, intracanalicular and intracranial. The intraocular portion of the optic nerve is affected in papillitis as optic nerve head swelling is visible with funduscopic evaluation. In retobulbar optic neuritis, the intraocular portion of the nerve is spared, but the posterior myelinated segments are affected.

As the most common cause for a swollen nerve in children is a preceding viral infection, it seems reasonable that vaccines can also cause the same condition by stimulating the immune system. Although the exact mechanism is unknown, it is believed that the peripheral activation of T-cells may cross the blood-brain barrier, resulting in a delayed type 4 hypersensitivity reaction. The myelin surrounding the optic nerve is damaged by this reaction, and eventually the axon may also be compromised — damage that is evident on OCT.[10] Predictably, optic atrophy is quite common in pediatric optic neuritis, with up to 89% of patients showing evidence of atrophy.[24] Interestingly, in the pediatric population the degree of optic atrophy does not always strongly correlate with the level of visual acuity loss. [25]

Presentation

Optic neuritis in adults usually presents with unilaterally reduced vision, an APD on the affected side and a normal-appearing optic nerve head. In the Optic Neuritis Treatment Trial (ONTT), which enrolled 457 adult patients, the most common symptoms of optic neuritis were vision loss and eye pain. In this trial, the median visual acuity in the affected eye was 20/60 but ranged from 20/20 to light perception.[26] Photopsias and reduced color vision were present in 30% and 88% of patients in the ONTT, respectively.[26] Vision loss initially progressed but began improving after two weeks.

This differs from the classic presentation of optic neuritis in children, which is bilaterally reduced vision with swollen optic nerve heads. A small study found that 66% of optic neuritis was bilateral in children, and 64% had a swollen optic nerve head, while only 1/3 of adults present with a swollen optic nerve head.[27] Initial visual acuity is more often profoundly depressed in children than in adults.[28] Although rare, optic neuritis is more likely to be a neuro-retinitis in children than in adults in which the optic nerve head edema is accompanied by retinal exudates and/or retinal hemorrhages. A headache is usually associated with pediatric optic neuritis, another distinction from the most common presentation of optic neuritis in adults.

Treatment

No large-scale clinical trial has focused on optic neuritis in the pediatric population; therefore, evidence is largely limited to case reports, case studies or cohort studies.

The ONTT provides strong evidence regarding the treatment of optic neuritis in adults, but unfortunately this evidence may not extrapolate to children because no pediatric patients were included. Some small trials have indicated that a conservative approach of no treatment is best in pediatric cases, but others have found a benefit to intravenous methylprednisolone.[29-30] If involvement is bilateral and visual acuity is dramatically reduced, treatment is more likely to be beneficial.[29-30]

Although there is a lack of strong evidence advocating for treatment of optic neuritis in children, treatment with intravenous

methylprednisolone for three to five days is a common treatment. A course of oral steroids with taper is often prescribed following the IV administration to reduce the likelihood of recurrence.[30] The treatment itself is the same in adults and children, but in children the duration of treatment is typically longer with a slower taper. [30] This treatment is somewhat controversial because optic neuritis is largely self-limiting, but steroids are more likely to be prescribed in bilateral cases with severe visual reduction.

Prognosis

The prognosis in cases of pediatric optic neuritis is quite favorable. In general, pediatric patients tend to recover the majority of their vision in weeks and often have no lingering symptoms even though imaging can detect lasting damage from the period of inflammation. In a study by Jo et al, 80% of patients recovered 20/40 vision or better over an average of 2.30 months.[32] The average final acuity in this study was 20/25.[32] One study suggested that unilateral involvement is associated with a better visual prognosis than bilateral involvement.[27] In a long-term follow-up study of 39 children with optic neuritis, 77% had no additional episodes of optic neuritis and only six patients (15%) developed MS.[32] In this same study, a surprising 55% of patients had a normal visual evoked potential despite a prior episode of optic neuritis. This finding may indicate that the optic nerve is more resilient in childhood than adulthood. As in adults, optic neuritis may be the first sign of MS, but the association is much weaker. Although the likelihood of developing MS following a single episode of optic neuritis approaches 40% in adults, in children the statistics are less reliable due to the lack of large-scale clinical trials. A meta-analysis found that 29% of children with isolated optic neuritis developed MS, but the range in children has been reported to be as low as 4% and as high as 43%.[33-34] In a small study of 15 patients with optic neuritis, unilateral involvement and older age at presentation conferred a higher risk of developing MS.[27] These findings, however, are in conflict with a larger study that included 36 patients and found those with bilateral involvement were more likely to develop MS and that age of presentation was not predictive of MS risk.[35] Even though the exact risk of MS in these pediatric patients is unknown, it is important to obtain an MRI of the brain to rule out any white matter lesions. Normal neuro-imaging at the time of optic neuritis seems to be indicative of a reduced risk of MS. One study found that no pediatric patients developed MS who had normal neuro-imaging initially.[35]

The most common clinical findings after an acute episode of optic neuritis are optic atrophy, decreased color vision and altered pupillary cycling.[36] A patient's visual acuity may return to normal, but he or she may still perceive a subjective difference in quality of vision between the two eyes. Tests such as contrast sensitivity and color vision can help detect this subtle deficit in visual function of the affected eye.

Conclusion

Optic neuritis can have a variety of presentations and etiologies, but its hallmark is inflammation of the optic nerve. In this case report, a parainfectious etiology related to vaccinations was most likely responsible for the patient's bilateral papillitis in childhood. Optic neuritis should be treated properly in its acute phase, and then patients should be monitored long-term for the development of optic atrophy and systemic demyelinating diseases such as MS and NMO.

References

1. Chan JW. Optic Nerve Disorders-Diagnosis and Management. New York: Springer Science + Business Media;2007. Chapter 1, Optic Neuritis.

2. Kanski JJ. Clinical Ophthalmology: A Systemic Approach. Sixth Edition. Philadelphia:Elsevier Limited; 2007. Chapter 21, Neuro-ophthalmology.

3. Miller NR, Newman NJ, editors. Walsh and Hoyt's Clinical Neuro-Ophthalmology. Sixth Edition. Philadelphia: Lippincott Williams and Wilkins; 2005. Chapter 6, Optic Neuritis

4. Grosberg BM, Solomon S, Lipton RB. Retinal Migraine. Current pain and headache reports. 2005:9(4):268-71.

5. Olesen J, Tfelt-Hansen P, Welch KM, et al. The Headaches. New York, NY: Raven Press Ltd; 1993:421-426.

6. Wakakura M, Ishikawa S, Oono S. Incidence of acute idiopathic optic neuritis and its therapy in Japan. Optic Neuritis Treatment Trial Multicenter Cooperative Research Group. Nihon Ganka Gakkai Zasshi.1995;99:93-97.

7. Bojic L, Ivanisevic M, Sinicic A. The incidence of optic neuritis in Split-Dalmatia county, Croatia. Coll Antropol. 2004;28:343-347.

8. Kinnunen E. The incidence of optic neuritis and its prognosis for multiple sclerosis. Acta Neurol Scand.1983;68:371-377.

9. Brodsky MC. Pediatric Neuro-ophthalmology. Second Edition. New York: Springer Science + Business Media; 2010. Chapter 3, The Swollen Optic Disc in Childhood.

10. Perez-Cambrodi RJ, Cubillana A, Merino-Suarez ML, et al. Optic neuritis in pediatric population: A review in current tendencies of diagnosis and management. Journal of Optometry. 2014;7:125-130.

11. Trip SA, Schlottmann PG, Jones SJ, Altmann DR, Garway-Heath DF, Thompson AJ, et al. Retinal nerve fiber layer axonal loss and visual dysfunction in optic neuritis. Ann Neurol. 2005;58:383-91.

12. Hood DC, Kardon RH. A framework for comparing structural and functional measures of glaucomatous damage. Progress in Retinal and Eye Research. 2007;26(6):688-710.

13. Costello W, Hodge Y, Pan I, et al. Tracking retinal nerve fiber layer loss after optic neuritis: a prospective study using optical coherence tomography. Multiple Sclerosis. 2008;14(7):893-905.

14. Ajtony C, Balla Z, Somoskeoys S, et al. Relationship between visual field sensitivity and retinal nerve finer layer thickness as measured by OCT. Invest Ophthalmol Vis Sci. 2007;48:258-263.

15. Trobe JD, Beck RW, Moke DS, et al. Contrast sensitivity and other vision tests in the Optic Neuritis Treatment Trial. Am Journal of Ophthalmology. 1996;121(5):547-553.

16. Fischer JB, Jacobs DA, Markowitz CE, et al. Relation of visual function to retinal nerve fiber layer thickness in multiple sclerosis. Ophthalmology. 2006;113(2):324-332.

17. Trobe JD, Glaser JS, Cassady J, Herschler J, Anderson DR. Nonglaucomatous excavation of the optic disc. Arch Ophthalmol. 1980;98(6):1046-50.

18. Greenfield DS. Glaucomatous versus nonglaucomatous optic disc cupping: clinical differentiation. Semin Ophthalmol. 1999;14:2:95-108.

19. Ratchford JN, Quigg ME, Conger A, et al. Optical coherence tomography helps differentiate neuromyelitis optica and MS optic neuropathies. Neurology. 2009;73:302-308.

20. Miravalle A, Biller J, Schnitzler E, Bonwit A. Neurological complications following vaccinations. Neurol Research. 2010;32(3):285-292.

21. Pillar GP, Toubi E. Vaccination-induced bilateral optic neuritis: rare but existing. IMAJ. 2012;14:690-691.

22. Payne DC, Rose CE, Kerrison J, et al. Anthrax vaccination and the risk of optic neuritis in the United States Military 1998-2003. Arch Neurol. 2006;63:871-875.

23. Bale JF. Neurologic complications of immunization. J Child Neurol. 2004;19:405-412.

24. Boomer J, Siatkowski M. Optic neuritis in adults and children. Seminars in Ophthalmology. 2003;18(4):174-180.

25. Taylor D, Cuendel F. Optic neuritis in childhood. In: Hess RF, Plant GT, eds. Optic Neuritis. Cambridge: Cambridge University Press. 1986;73-85.

26. Optic Neuritis Study Group. The clinical profile of optic neuritis: experience of the Optic Neuritis Treatment Trial. Arch Ophthalmol. 1991;109:1673.

27. Morales DS, Siatkowski RM, Howard CW, et al. Optic neuritis in children. J Pediatr Ophthalmol Strabismus. 2000;37(5):254-259.

28. Boomer J, Siatkowski M. Optic neuritis in adults and children. Seminars in Ophthalmology. 2003;18(4):174-180.

29. Hickman SJ, Dalton CM, Miller DH, Plant GT. Management of acute optic neuritis. Lancet. 2002;360:1953-1962.

30. Bonhomme GR, Mitchell EB. Treatment of pediatric optic neuritis. Curr Treat Options Neurol. 2012 Feb;14(1):93-102.

31. Jo DH, Kim SJ, Chae JH, et al. The clinical characteristics of optic neuritis in Korean children. Korean J Ophthalmol. 2011;25(2):116-120.

32. Kriss A, Francis DA, Cuendet F, et al. Recovery after optic neuritis in childhood. J Neurol Neurosurg Psychiatry. 1988;51:1253-1258.

33. Riikonen R, Donner M, Erkkilä H. Optic neuritis in children and its relationships to multiple sclerosis: a clinical study of 21 children. Dev Med Child Neurol. 1988;30:349-359. doi: 10.1111/j.1469-8749.1988.tb14560.x.

34. Waldman AT, Stull LB, Galetta SL, et al. Pediatric optic neuritis and risk of multiple sclerosis: meta-analysis of observational studies. J AAPOS. 2011;15(5);441-446.

35. Wilejto M, Shroff M, Buncic JR, et al. The clinical features, MRI findings, and outcome of optic neuritis in children. Neurology. 2006;67:258-262.

36. Kirkham TH, Coupland SG. Multiple regression analysis of diagnostic predictors in optic nerve disease. Can J Neurol Sci. 1981;8(1):67-72.

A Pilot Study of Optometry Student Perceptions, Acceptance and Use of Podcasting

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Background

"Lecture capture" is a process in which digital recordings of live lectures are shared with students. Its purpose is to increase engagement with lecture material and to increase student satisfaction.[1] "Full" lecture capture includes video and audio,[2,3] but it can be challenging to introduce because it requires suitable infrastructure such as cameras and microphones in lecture theaters and upgrades to computer hardware. Working with video files can be time-consuming for staff and requires technical expertise. Finally, video files are large, so students without a good quality internet connection may find them difficult to access.[2,4]

A more accessible alternative to full lecture capture is "podcasting." The term "podcast" is defined as "a digital audio file of speech, music, broadcast material, etc., made available on the Internet for downloading to a computer or portable media player; a series of such files, new installments of which can be received by subscribers automatically."[5] The average smartphone, tablet or computer can record and edit high-quality audio, which common e-learning platforms can then distribute as a podcast. The flexibility of audio allows podcasts to be updated as needed,[6] maintaining the relevance to students.[3,7,8]

Podcasts are used to support learning in a wide range of healthcare disciplines, including medicine,[3,9-11] nursing[2,4,7,12-15] and dentistry.[16] The most common use has been to support students with basic science and pre-clinical modules.[2,7,9,10,12,16] Use of podcasts for undergraduate clinical education is rare,[15] and there are no documented cases in optometry.

Podcasting is popular with students and can increase student satisfaction and engagement.[6,11,13,17,18] This popularity stems from perceived benefits including mobility[4,6,7,12,14,15,19-21] and flexibility.[2,4,7,13,19-22] Students value the ability to re-visit lectures and revise lecture notes,[2-4,6,7,9,12,14,17,18,21,23,24] which may also help to reduce anxiety.[6,10,15,16] Finally, auditory learners may appreciate learning resources in an audio format.[3,11-15,19,21]

Even though students believe that podcasts can improve academic performance,[2,4,7,10,13,16,17,21] evidence of an objective improvement is lacking.[4,13,17,25] This may be because lecture podcasts may duplicate,[25] or replace,[17] traditional teaching resources. The flexibility of "on demand" resources can also pose risks. For example, the mobility of podcasts can interfere with concentration by encouraging listening in distracting environments.[13,17,26] The ability to choose when to study may allow students to pace their learning inappropriately.[4] Concerns have also been raised about the effect of podcasts on lecture attendance[4,21,23] because non-attendance may increase the likelihood of poor academic performance, disengagement and discontinuation.[17,21,27] Non-attendance in clinical modules may be riskier due to the visual nature of procedural instruction.[2] Despite these concerns, podcasting in other courses has caused little to no decrease in the number of attendees in most cases.[4,6,7,10,15,16,21,24]

There are many ways to measure academic progress in higher education. Final outcome measures such as grades are important, but it is also essential to understand and optimize the individual factors that contribute to the overall academic success of a student; these include student engagement and satisfaction.[28] The purpose of this study was to assess participant perceptions of a podcasting pilot program in optometry.

Methods

Participants and ethics

In the first week of the new academic year, a printed survey was distributed to all Year 2 students (n=83). Seventy-one of the respondents (85.5%) indicated that they had completed the OP1201 Basic Clinical Techniques module, undergraduate optometry program, Cardiff University, in the previous academic year. OP1201 is a compulsory 22-week module that equips Year 1 students with the clinical skills and knowledge required to conduct a basic optometric eye examination; it assumes no prior experience. The module is taught using one-hour lectures and two-hour practical (clinical) classes. The theory and technique for each clinical procedure are described in one or more lectures, and the procedure is later performed by students in a practical class under the guidance of qualified optometrists. All PowerPoint presentations delivered in the lectures, as well

as additional written information and revision exercises, were published online (Blackboard™) before face-to-face sessions. Students who had completed the OP1201 module in the previous year but who had not progressed to Year 2 (n=7), or who were attempting Year 2 for the second time (n=2), were not captured by this study.

The Research Audit Ethics Committee at the School of Optometry and Vision Sciences, Cardiff University, granted ethical approval for this study, and the research was conducted in accordance with the tenants of the Declaration of Helsinki. Potential participants were informed of the nature of the study verbally and in writing, and consent was implied by submission of a completed survey. As a condition of ethical approval, the participants were informed that their opinions would be considered when determining the future of the podcasting pilot program. To limit the possibility of systematic bias as a result of being aware of the study's purpose, students were presented with the full range of potential outcomes verbally and through the survey questions.

Survey design

The survey design was based on the Technology Acceptance Model (TAM),[29,30] a method used previously to assess the student perceptions of podcasting in higher education.[12,17,22] The TAM considers a broad range of issues, including current usage patterns, barriers to use and untapped potential. This survey also contained questions directed towards students who had not used the podcasts.[3] The final survey consisted of a mixture of four-point Likert scale questions and questions in an open-ended format and was conducted anonymously. Local nomenclature required that the word "practical" be used on the surveys rather than the word "clinical," although these terms are interchangeable for the purposes of this study.

Podcast production

The podcasts were recorded during lectures for the OP1201 module using the native Voice Recorder app (version 0.1) and built-in microphone of a Samsung Galaxy SIII smartphone placed on the lectern. The recordings were transferred to a computer for conversion from the proprietary 3gp format to generic mp3 using Format Factory for Windows (version 2.96, available for free at http://www.pcfreetime.com). The mp3 was edited using Audacity for Windows (version 2.0.2, available for free at http://audacity.sourceforge.net/) to remove unnecessary material at the start and end of the lecture. Each podcast was uploaded to the online learning platform Blackboard™ (version 9) using the plug-in "Campus Pack Podcasts" within two weeks of the lecture, where it could be downloaded manually or via a podcast subscription service. Students were advised that podcasts were intended to accompany the PowerPoint presentation delivered in the lecture.

Data analysis

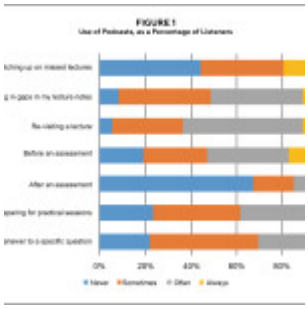
The responses to all survey questions were summarized and presented using Microsoft Excel 2013 for Windows. For each question, the proportion of responses for each category on the Likert scale was calculated as a percentage of the number of total valid responses. Responses to open questions are presented as quotations in this paper, as there were too few to conduct a thematic analysis.

Results

Use of podcasts

52.1% (37/71) of the participants stated they had downloaded and listened to at least one podcast; they are referred to as "Listeners." The remaining 47.9% (34/71) did not listen to any podcasts; they are referred to as "Non-listeners."

Listeners



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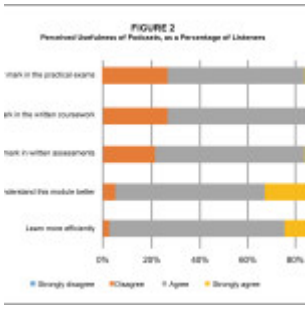

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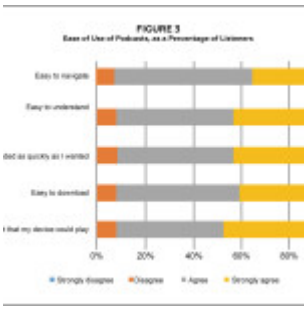

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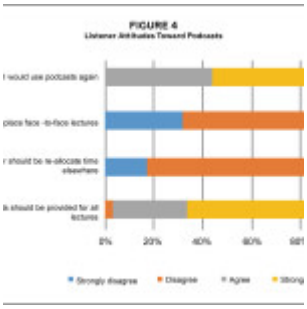

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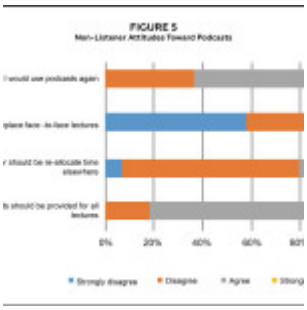

Click to enlarge

Of the Listeners (n=37), 100% had used a computer to access the podcasts. Mobile devices, such as dedicated portable audio players (8.1%), smartphones (8.1%) and tablet computers (2.7%), were used sparingly. **Figure 1** shows that the primary use of podcasts by Listeners (defined as “often” or “always”) was for filling in gaps (51.3%) and re-visiting (63.9%) lectures. Podcasts were used frequently before assessment tasks (52.8%) but less commonly afterward (14.7%). Some Listeners routinely used podcasts to prepare for practical sessions (38.3%). Among the Listeners, 36.1% reported using podcasts to catch up on missed lectures “sometimes,” while 19.4% reported that they “always” did so.

Figure 2 shows that most Listeners agreed or strongly agreed that podcasts increased understanding (94.6%) and learning efficiency (97.3%). Many Listeners felt that their academic performance in practical (73%) and written coursework or assessments (73% and 78.4%) was enhanced by the podcasts, as indicated by the level of agreement with survey questions relating to obtaining a “better mark.”

Figure 3 shows that Listeners agreed or strongly agreed that the podcasts were easy to navigate (91.9%), understand (91.8%), download (91.9%), were uploaded quickly (91.5%) and were in a useful format (91.5%). A small number of Listeners (<9%) reported minor difficulties with accessing or using the podcasts.

Non-listeners

The main reasons that Non-listeners did not use podcasts were a lack of familiarity with accessing material in this way (34.3%), a lack of time (31.4%) and dislike of accessing or using them (28.6%). Minor reasons included technical difficulties (2.9%) and a lack of awareness of podcasts (2.9%).

Figures 4 and 5 show that the majority of participants (97.3% of Listeners and 80.7% of Non-listeners) agreed or strongly agreed that podcasts should be provided for all lectures and expressed a desire to use them in the future (100% of Listeners and 63.4% of Non-listeners). Both groups agreed that the preparation of podcasts was a good use of lecturer time (82.8% of Listeners and 80% of Non-listeners). In response to the question of whether podcasts would be a suitable replacement for face-to-face lectures, 85.7% of Listeners and 83.9% of Non-listeners disagreed.

Discussion

Although podcasting has been used in healthcare education for some time, its main function has been to support the teaching of basic science and pre-clinical modules.[2,7,9,10,12,16] Little is known about the use of podcasts for clinical education,[15] and nothing on the topic and optometry had been published. This study explored the introduction of podcasts in optometric education from a student perspective and found podcasts to be a popular supplement to traditional clinical teaching.

Use of podcasts

Approximately half of the survey respondents (52.1%) reported listening to at least one podcast, with a significant proportion using podcasts frequently ("often" or "always," **Figure 1**). The uptake of podcasts in this study is similar to the prevalence of Listeners reported within other Year 1 UK-based healthcare education courses, including 64.6% and 51.5% for two basic science modules in a medical degree program at the University of Leeds,[9] and 71% reported at the University of Nottingham for Nursing students studying a biology module.[12] The number of students accessing podcasts in this study was considerably lower than figures reported by institutions in the United States, such as the 89.4% reported in a basic science course at the Vanderbilt University School of Medicine,[10] and the 95% reported at the School of Nursing at Adelphi University.[7] These figures suggest podcasts were well-accepted by optometry students but there may be potential for increasing adoption.

Smartphones and tablets have not changed listening habits

One of the original benefits of podcasting was the flexibility it offered, allowing students to study anywhere and at any time.[13,17,26] Research has since shown that most students prioritize the ability to concentrate over the ability to be mobile,[4,6,7,9,11-13,16,17,21-24,26] and this study confirmed that the primary device for accessing podcasts remains the computer (100%). Students used mobile devices sparingly and always as a supplement to a computer. The preference for computer-based listening could have been anticipated for this study, as the podcasts were designed to be paired with the PowerPoint presentations published on Blackboard™ [7,9,21,23]

> *"I liked that I could listen and read the PPP (PowerPoint Presentation) at the same time."*

Podcasts are relevant to practical and clinical performance

The Listeners reported that podcasts improved understanding (94.6%), learning efficiency (97.3%) and grades in written coursework and assessments (73% and 78.4%, **Figure 2**). Such a finding is common.[2,6,7,10,16,17] Students also reported a belief that podcasts improved practical and clinical performance. A noteworthy proportion of Listeners (38.3%, **Figure 1**) used podcasts frequently to prepare for practical sessions, while many more reported that podcasts improved their results in practical assessments (73%, **Figure 2**). As this was a pilot program, technical limitations sometimes delayed the publication of the podcasts by up to two weeks. It would be useful to investigate whether a more rapid distribution of podcasts would increase the proportion of students who used them to prepare for practical sessions.

Podcasts are a useful companion to lectures

Previous studies have indicated a major use of podcasts is to re-visit lectures and update lecture notes,[2-4,6,7,9,12,14-18,21,23,24] and

more than 90% of Listeners in this study did so **(Figure 1)**. In particular, podcasts allowed students to identify and correct missed information in lecture notes.

> *"I could list(en) to my lectures again and get any points I may have missed the first time around."*

Another interesting point raised was that the podcasts allowed students to pay greater attention during lectures, as they did not need to be concerned about missing vital material.[6,7,14,16,21,23] This is likely to be particularly important for students for whom English is not their first language or for students with learning difficulties.[7,15,21]

> *"That you can go back and edit notes – meaning in the lecture you can concentrate and try to understand rather than trying to write everything down."*

As has been reported previously,[7,15,21] a significant number of Listeners (52.8%, **Figure 1**) regularly used podcasts for revision purposes before assessments. This is unsurprising given that the Listeners also reported a belief that podcasts improved their assessment performance **(Figure 2)**. However, only 14.7% of Listeners indicated that they would routinely use a podcast after an assessment **(Figure 1)**, which could be viewed as a missed opportunity for students to reflect on their practical performance within the context of the theoretical aspects of the module. It would be beneficial to educate the students regarding this untapped benefit of podcasting.

Podcasts as a substitute for lectures

In the Listener group and the Non-listener group, 85.7% and 83.9%, respectively, expressed an opinion that podcasts were not a suitable replacement for lectures **(Figure 5)**, with 44.4% of Listeners reporting they have never used podcasts for this purpose. In contrast, 36.1% reported they had done so "sometimes" **(Figure 1)**. This suggests that most students prefer to attend live lectures but will use a podcast as an alternative when an absence is unavoidable.[4,6,7,12,14,21,23]

However, a subset of Listeners routinely used podcasts as a substitute for attending lectures; 19.4% reported they "always" used podcasts to catch up on lectures **(Figure 1)**, and 14.3% **(Figure 5)** accepted podcasts as a replacement for lectures. This figure is at odds with previous studies that have reported that podcasts do not cause a decline in lecture attendance.[6,7,10,16,21,24] Although using podcasts as a substitute for attending lectures can provide students with the freedom to study anywhere,[4,6,7,12,14,15,19-21] and at any time,[2,4,7,13,19-22] it can be a risky strategy. First-year students are particularly vulnerable to the disengagement and isolation that self-directed study can bring.[21,27] Listening to a podcast instead of attending a lecture, even when viewed with the accompanying PowerPoint presentation, may pose additional problems for modules of a visual nature.[2] Finally, the lack of face-to-face contact between the lecturer and the students can prevent important real-time communication between the two.[2,20]

Why don't some students listen to podcasts?

Although the Listeners reported that the podcasts were easy to navigate (91.9%), understand (91.8%), download (91.9%), were available quickly (91.5%) and in a useful format (91.5%, Figure 3), there were three primary reasons that 47.9% of students (Non-listeners) did not use them.

First, approximately one-third of the Non-listeners (34.3%) reported a lack of familiarity with using podcasts. It is sometimes incorrectly assumed that the current generation of university students is extremely familiar with technology, but this can be a barrier to engagement.[2] Training for students may improve the uptake of podcasts.[4,12]

Second, although the majority of Listeners (97%) felt that the podcasts enabled them to learn more efficiently **(Figure 2)**, 31.4% of the Non-listeners reported that lack of time was a barrier.[4,14] The compatibility of podcasting with preferred learning styles might explain some of this discrepancy. Learning styles may be classified as visual, auditory, read & write or kinesthetic (VARK) based on whether a student prefers to learn via images, sound, note taking or touch.[31] Auditory learners may have seen efficiency gains because non-optimal traditional resources were replaced with a learning resource in their preferred format.[19] Conversely, students with non-auditory learning styles may have viewed podcasts as an additional and inferior learning resource.[13] Academic ability may offer an alternative explanation for differences in uptake. Studies have shown that students with higher levels of academic ability can process material more quickly, allowing time to engage with additional resources.[1] It is thought, however, that lower achieving students would be likely to derive more benefit.[1] The anonymous survey design meant that it was not possible to explore differences in characteristics between Listeners and Non-listeners. Further work is

recommended to evaluate the relationship between learning style, academic ability and the uptake of podcasts.

Finally, 28.6% of students reported a dislike of accessing or using materials provided as a podcast. This may reflect a lack of acceptance of the technology itself or the mismatch between podcasts and personal learning preferences.

> *"I personally don't use them because I prefer reading and making notes from books/doing questions."*

Future of the podcasting program

Listeners (97.3%, **Figure 4**) and Non-listeners (80.7%, **Figure 5**) agreed that the podcast program should be expanded. All (100%) Listeners and 63.4% of Non-listeners indicated they would use podcasts in the future. The support of Non-listeners for podcasts was surprising and the reason is altruistic:

> *"I like that podcasts are available for people who would use them to refresh their memory or make additional notes that they may have missed."*

There is some doubt relating to whether students felt that the preparation of podcasts was a good use of lecturer time. 82.8% of the Listeners and 69% of the Non-Listeners agreed with this statement. Additional work would be useful to determine which activities students would rather see from a lecturer.

Limitations and further work

As a condition of ethical approval, students were informed that their survey responses would be considered when evaluating the future of the podcasting pilot program. To avoid systematic bias, all possible outcomes (continuation, expansion or discontinuation) were included when the podcasting pilot program was explained to the students. Also, leading questions within the survey were avoided. Nevertheless, the reader is encouraged to consider the possibility of bias when interpreting the results.

Podcasts are becoming increasingly easy to record, distribute and access, and are popular with optometry students. However, further work is recommended prior to generalizing the results of this study. It would be useful to evaluate whether podcasts have a measurable impact upon clinical performance or assessment results. Other areas to be considered include the consequences of non-attendance in visual modules,[2] or whether full lecture capture may be more appropriate.

Conclusions

Podcasts are a popular supplement to conventional clinical teaching in optometric education.

References

1. Owston R, Lupshenyuk D, Wideman H. Lecture capture in large undergraduate classes: student perceptions and academic performance. Internet High Educ. 2011;14(4):262-8.

2. McKinney AA, Page K. Podcasts and videostreaming: useful tools to facilitate learning of pathophysiology in undergraduate nurse education? Nurse Educ Pract. 2009;9(6):372-6.

3. Matava CT, Rosen D, Siu E, Bould DM. eLearning among Canadian anesthesia residents: a survey of podcast use and content needs. BMC Med Educ. 2013;13(1):59. Available from: http://www.biomedcentral.com/1472-6920/13/59.

4. Meade O, Bowskill D, Lymn JS. Pharmacology as a foreign language: a preliminary evaluation of podcasting as a supplementary learning tool for non-medical prescribing students. BMC Med Educ. 2009;9(74). Available from: http://www.biomedcentral.com/1472-6920/9/74.

5. Oxford University Press. podcast, n. Oxford University Press; 2015 [accessed May 11 2015]. Available from: http://www.oed.com/view/Entry/273003?rskey=5dSgvl&result=1#eid.

6. Chan A, Lee MJW. An mp3 a day keeps the worries away: exploring the use of podcasting to address preconceptions and alleviate pre-class anxiety amongst undergraduate information technology students. In: Good Practice in Practice. Proceedings of the Student Experience Conference. Wagga Wagga, NSW, Australia. Spennemann DHR, Burr L, editors. 2005. pp. 58-70.

7. Forbes MO, Hickey MT. Podcasting: Implementation and evaluation in an undergraduate nursing program. Nurse Educ. 2008;33(5):224-7.

8. Chan A, Lee MJW, McLoughlin C. Everyone's learning with podcasting: a Charles Sturt University experience. In: Proceedings of the 23rd Annual ASCILITE Conference. Who's learning? Whose technology? Sydney, NSW, Australia. Markauskaite L, Goodyear P, Reimann P, editors. 2006. pp. 111-120.

9. Bickerdike S, Whittle SR, Pickering JD. Do lecture audio-recordings support engagement and flexible learning? Med Educ. 2014;48(5):522-3.

10. Pilarski PP, Johnstone DA, Pettepher CC, Osheroff N. From music to macromolecules: using rich media/podcast lecture recordings to enhance the preclinical educational experience. Med Teach. 2008;30(6):630-2.

11. White JS, Sharma N, Boora P. Surgery 101: evaluating the use of podcasting in a general surgery clerkship. Med Teach. 2011;33(11):941-3.

12. Mostyn A, Jenkinson CM, McCormick D, Meade O, Lymn JS. An exploration of student experiences of using biology podcasts in nursing training. BMC Med Educ. 2013;13(1):12. Available from: http://www.biomedcentral.com/1472-6920/13/12.

13. Vogt M, Schaffner B, Ribar A, Chavez R. The impact of podcasting on the learning and satisfaction of undergraduate nursing students. Nurse Educ Pract. 2010;10(1):38-42.

14. Meade O, Bowskill D, Lymn JS. Pharmacology podcasts: a qualitative study of non-medical prescribing students' use, perceptions and impact on learning. BMC Med Educ. 2011;11(1):2. Available from: http://www.biomedcentral.com/1472-6920/11/2.

15. Maag M. iPod, uPod? An emerging mobile learning tool in nursing education and students' satisfaction. In: Proceedings of the 23rd Annual ASCILITE Conference. Who's learning? Whose technology? Sydney, NSW, Australia. Markauskaite L, Goodyear P, Reimann P, editors. 2006. pp. 483-92.

16. Brittain S, Glowacki P, Van Ittersum J, Johnson L. Podcasting lectures. Educause 2006. 2006;3:24-31. Available from: http://www.educause.edu/ero/article/podcasting-lectures.

17. Kemp PK, Myers CE, Campbell MR, Pratt AP. Student perceptions and the effectiveness of podcasting in an associate degree nursing program. Teach Learn Nurs. 2010;5(3):111-4.

18. Belanger Y. Duke University iPod first-year experience final evaluation report. 2005 [accessed Mar 10 2015]. Available from: cit.duke.edu/pdf/reports/ipod_initiative_04_05.pdf.

19. Cebeci Z. Using podcasts as audio learning objects. IJELL. 2006;2(1):47-57.

20. Jham BC, Duraes GV, Strassler HE, Sensi LG. Joining the podcast revolution. J Dent Educ. 2008;72(3):278-81.

21. Scutter S, Stupans I, Sawyer T, King S. How do students use podcasts to support learning? Podcasting in teaching. IMEJ. 2010;26(2):180-91.

22. Gribbins M. The perceived usefulness of podcasting in higher education: a survey of students' attitudes and intention to use. In Proceedings of the Second Midwest United States Association for Information Systems, Springfield, IL, USA; 2007.

23. Lane C. UW podcasting: evaluation of year one. Report by Office of Learning Technologies; 2006 [accessed May 8 2015]. Available from: https://itconnect.uw.edu/wp-content/uploads/2013/12/podcasting_year1.pdf.

24. Smith K, Morris NP. Evaluation of biomedical science students use and perceptions of podcasting. BEE-j. 2014;22(1):3-15.

25. Abt G, Barry T. The quantitative effect of students using podcasts in a first year undergraduate exercise physiology module. BEE-j. 2007;10(Dec). Available from: www.bioscience.heacademy.ac.uk/journal/vol10/beej-10-8.pdf.

26. Lee MJW, Chan A. Pervasive, lifestyle-integrated mobile learning for distance learners: an analysis and unexpected results from a podcasting study. Open Learn. 2007;22(3):201-18.

27. Bevitt D, Baldwin C, Calvert J. Intervening early: attendance and performance monitoring as a trigger for first year support in the biosciences. BEE-j. 2010;15(Jun). Available from: http://www.tandfonline.com/doi/full/10.3108/beej.15.4.

28. Liu R. Satisfaction and performance: a reciprocal model. Paper presented at the 44th Annual AIR Forum, Boston, MA, USA, May 2004. Available from: http://files.eric.ed.gov/fulltext/ED490994.pdf.

29. Davis FD. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quart. 1989;13(3):319-40.

30. Saadé RG, Nebebe F, Tan W. Viability of the “Technology Acceptance Model” in multimedia learning environments: a comparative study research model and hypotheses. IJELL. 2007;3:175-84.

31. Fleming N, Baume D. Learning styles again: VARKing up the right tree! Educational Developments, SEDA Ltd. 2006;7.4(Nov):4-7. Available from: http://www.johnsilverio.com/EDUI6702/Fleming_VARK_learningstyles.pdf.