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in Integrated Care

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This ongoing series, now in its second year, is featured in each issue of *AOC* and its sister publication, *CRST*. The articles will clarify how eye care providers can best work together to provide patient-centered care of the highest quality possible.

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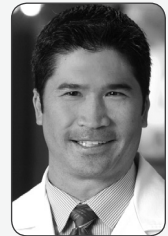
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IMAGING'S ROLE IN THE DIAGNOSIS AND MANAGEMENT OF GLAUCOMA

OCT is important for managing patients with mild to moderate glaucoma but its application is more limited in severe disease.

BY MURRAY FINGERET, OD



Two primary modalities are used for imaging glaucoma patients: retinal photographs and optical coherence tomography (OCT). Each has a role, and both can be complementary to the examination findings and the management plan. Both photography and OCT have important strengths and limitations that are relevant to how they are used at different stages of glaucoma.

An advantage of retinal photography is that it is a stable platform. It has been around for many years and photographs

taken 25 years ago are still relevant. That cannot be said for imaging devices purchased 25 years ago. With advances in the technology used for image capture, the optic nerve, retinal nerve fiber layer, and the macula can be visualized better than ever before.

OCT provides extremely useful clinical information, and its versatility has allowed it to eclipse several other technologies used in glaucoma imaging. Scanning laser polarimetry for imaging the retinal nerve fiber layer (RNFL), for example, is less commonly used. Confocal scanning laser ophthalmos-

copy, as with the Heidelberg Retinal Tomograph (Heidelberg Instruments), is an excellent tool for tracking progression over time, but its single functionality makes it less desirable for the average clinic than the more flexible OCT.

There is some thought that OCT imaging is so useful that retinal photography is no longer indicated. I find retinal photographs to be invaluable, and I utilize both photography and OCT as I monitor individuals with glaucoma. Certain findings such as disc hemorrhages are best seen with photography. Also, some clinicians have taken to performing OCT in lieu of performing visual field examinations, under the mistaken notion that this advanced technology can be a substitute for other parts of the examination and can by itself drive clinical decision-making. However, there is no rationale for replacing a functional test with one that provides information only on structure. Moreover, any and all imaging is still subject to interpretation by the investigator. Even if said imaging provides a perfect representation of the retina, fundus, and optic nerve, at its best, imaging is additive to the physician's clinical impression and findings.

OCT IN DIAGNOSIS AND FOLLOW-UP

Spectral-domain OCT (SD-OCT) offers granular detail about the health of the RNFL and ganglion cell complex. The technology can image the macula to demonstrate whether there has been tissue loss that may be attributable to glaucoma. The normative databases used by SD-OCT platforms greatly facilitate the clinician's ability to classify disease and severity. Most SD-OCT devices also contain some form of tracking software, which functions both to correct for ocular micromovements (eliminating noise and image artifacts) and to ensure that serial imaging is performed based on a consistent reference point. The former provides greater image clarity, and the latter improves the ability to track progression over time.

OCT is valuable as a diagnostic tool. For diagnostic purposes, OCT provides insights on rim thickness, rim area, and cup volume. The technology is also useful for tracking progression over time and fine-tuning therapy. If serial imaging confirms no change from one visit to the next, there may be no reason to alter a patient's established therapeutic approach. I may adjust therapy in response to OCT findings even when functional correlates (ie, visual field testing) do not demonstrate change.

However, OCT is useful only in the early stages of glaucomatous disease. It starts to lose applicability in more advanced stages. In a healthy eye, the RNFL is about 100 to 110 μm thick, but glaucoma results in irreversible thinning of the layer. The RNFL is detectable on OCT down to about 50 to 55 μm thickness, which corresponds in most eyes with moderate glaucoma. Subsequent optic neuropathy in more advanced stages of glaucoma does not result in any further detectable thinning of the retinal nerve on OCT because the imaging depicts remnant glial tissue.

“Of course, for visual field testing to be relevant in advanced disease, it is helpful to have a baseline to compare against.”

This so-called *floor effect* limits the applicability of OCT for imaging advanced glaucoma. OCT can demonstrate progression only to moderate disease, when patients typically still have a lot of visual field. At that point, visual field testing becomes more relevant for monitoring disease progression.

Of course, for visual field testing to be relevant in advanced disease, it is helpful to have a baseline to compare against. Therefore, visual field testing should be initiated early in the disease course. No single imaging or testing modality functions in isolation in the management of patients with glaucoma.

FUTURE INNOVATIONS

There are two innovations in OCT that may add to its clinical utility in glaucoma. Swept-source OCT (SS-OCT), now available or in development by a number of manufacturers, uses a faster image capture mechanism via a moving reference lens. (SD-OCT uses a fixed reference lens to capture backscattered light, and images are mathematically reconstructed using Fourier calculations that determine how wavelengths of projected light behaved in reference to spatial objects in the field of reference.) Faster image capture means less image noise and the ability to perform more scans per second to allow more accurate reconstruction of images. In most models, SS-OCT has been paired with a 1080-nm laser light source, a wavelength that penetrates deep into retinal structures, including the choroid. It appears that SS-OCT may also penetrate media opacities such as cataracts.

Faster image capture also allows OCT devices capture hundreds of thousands of sequential images of the retinal vasculature. With this information, the series of static images can be reconstructed to provide insight into the function of the retinal vasculature over a period of time (ie, the duration of the scan). This makes OCT angiography (OCT-A) possible. The modality is somewhat akin to fluorescein angiography, in that it provides information about blood flow at the back of the eye. Unlike fluorescein angiography, OCT-A does not require use of an intravenous injection; however, it also does not provide dynamic moving images with which to assess vascular function. There appears to be rationale for OCT-A in a number of retinal pathologies, although it is uncertain whether and how OCT-A might be applicable to glaucoma.

CONCLUSION

SS-OCT, OCT-A, and other proposed novel modalities may change the paradigm of how patients with glaucoma are followed using imaging. However, as much as greater clarity in imaging and the ability to gain deeper understanding of ocular structures will enhance clinical impressions, it is likely that imaging will always play a complementary role to the physician's interpretive skill in the management of patients.

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PATIENT-CENTERED COLLABORATIVE GLAUCOMA CARE

Partnership in managing glaucoma can yield highly efficient, high-quality patient care.

BY SARAH DOUGHERTY WOOD, OD, MS, FAAO



The eye care field is facing a near crisis situation with regard to its capacity to care for patients with age-related conditions. Projected increases in the prevalence of diseases that result in visual impairment (Table), set against a backdrop of better detection and improved access to care, suggest that potential human resource shortages could result in inconsistent,

inadequate delivery of care. Fortunately, there is still time to adjust our care model, to find greater efficiencies and ensure minimal disruption in patient care with no compromises in the quality of that care.

The emergence of the medical model of optometry provides a unique opportunity to mimic trends in other parts of medicine, where non-MD providers deliver essential care. Up to 30% of primary care providers in internal medicine are either physician assistants or nurse practitioners; studies show that, when care is delivered by these kinds of providers, there is no tradeoff in quality.¹ Similar findings have been noted with regard to nurse anesthetists assisting in anesthesiology.²

There are already examples in eye care in which optometrists play a collaborative role in the management of patients, including in cataract and refractive surgery. It is estimated that 20% of optometrists practice in a setting that also includes an ophthalmologist, and 50% of ophthalmologists

employ an optometrist.³ Unlike in ophthalmology, which has a fixed number of residency openings and thus limited potential for growth, in optometry the number of practitioners is expected to grow from 40,000 today to 46,300 by 2022.⁴

THE MAYO MODEL

The collaborative care model of ophthalmology and optometry working together is predicated on finding solutions that maximize efficiency, while ensuring the highest degree of safety and quality of care, in order to deliver superior outcomes. The patient is always the focus. As the numbers mentioned above indicate, there is little question that optometry-ophthalmology partnerships can be successful when the two specialties work side by side in the same practice setting. A more pointed question is whether high quality care delivery can be achieved when ophthalmologists and optometrists work together in concert in the care of the same patients.

The Mayo Clinic of Rochester, under the leadership of Cheryl L. Khanna, MD, developed a collaborative care model in which optometrists who have received extra training in managing glaucoma patients work intimately in the care of these patients. In this highly structured program, two glaucoma specialists, one comprehensive ophthalmologist, and two optometrists share patient care responsibilities in a highly organized manner.

TABLE. US CURRENT AND FUTURE BLINDNESS AND EYE DISEASE EPIDEMIOLOGY

	Current (millions)	2050 (millions)	% increase
Visual Impairment ^a	3.22	6.95	116%
Blindness ^a	1.02	2.01	97.1%
Advanced AMD ^b	2.2	4.4	100%
Diabetic Retinopathy ^b	8.1	13.2	63%
Cataract ^b	25.7	45.6	78%
Glaucoma	2.9	5.5	93%

^a2015 data from the National Federation of the Blind
^b2014 data from the National Federation of the Blind

In this model, all new glaucoma/glaucoma suspect patients undergo baseline diagnostic testing and workup.⁵ If a definitive diagnosis of glaucoma is made, the patient is seen by one of the glaucoma specialists to set a target intraocular pressure (IOP) and create an individualized treatment plan. These patients are then followed by the optometrists and seen by the glaucoma specialist either every two years or earlier if progression occurs or surgery is indicated. If the patient is deemed a glaucoma suspect, he or she is referred for follow-up to one of the staff optometrists.

The outcomes with this simple model have been positive. Dr. Khanna and her team have streamlined their approach to get more patients access to specialized care, and she has opened new slots for surgery (personal communication). The Mayo team is publishing studies on its model soon, including a cost-effectiveness analysis and a presentation of their outcomes.

KELLOGG MODEL FOR GLAUCOMA CARE

At the Kellogg Eye Center, we have adopted a program that is similar to the Mayo model but less formally structured. I started working in the glaucoma clinic with the section chief, Sayoko Moroi, MD, PhD, in a collaborative care model about 2 years ago. Although I had been practicing optometry for about 12 years at the time, I underwent a 6-month mini-fellowship under Dr. Moroi's tutelage to ensure that we were on the same page as far as objectives, responsibilities, and philosophies regarding patient care. As much as this was a valuable learning experience for me, it also helped that Dr. Moroi introduced me to her patients to establish familiarity with her very loyal patient population.

Our program has a simpler structure than the Mayo setup,

mostly because only Dr. Moroi and I are working in the clinic. At first, we alternated patient visits, but now we arrange it so that she sees patients typically once a year, while I handle the rest of the visits unless her expertise is required.

As far as responsibilities, I routinely handle dilated examinations and gonioscopy, medication management, test interpretation, and patient education. I handle some post-operative care, including after selective laser trabeculoplasty, although Dr. Moroi typically performs the immediate follow-up with patients who have had invasive glaucoma surgeries such as tube shunt implantation and trabeculectomy.

Making our model work in practice requires attention to details. For example, we must be diligent about charting in order to facilitate good communication. Because we are rarely in the clinic at the same time, we schedule a face-to-face meeting at least once a month. We stay in touch by regularly communicating through phone and email. But these are minor efforts that allow us to achieve a large reward. With my collaboration on routine patient care, Dr. Moroi's schedule has been freed up to do more research and to take on additional surgical cases.

GAUGING OUTCOMES

There are several ways to determine whether a collaborative care model of glaucoma is successful. Several studies have quantified that optometric involvement in glaucoma care resulted in good outcomes. For example, a retrospective study evaluated glaucoma patient outcomes and management with primary optometric care in 500 patients at the Centre for Eye Health in Sydney, Australia. The study authors found that "high quality and reproducibility of diagnosis and management recommendation protocols were confirmed."⁶ A randomized, controlled study, the Bristol Shared Care Glaucoma Study, was conducted to determine whether community-based optometrists in the United Kingdom could make valid assessments of glaucoma patients. Those authors found that examination outcome measures were comparable in accuracy to those made at a hospital eye service.⁷

Patients generally have no complaints about seeing an optometrist rather than a glaucoma specialist; 81% of respondents to one survey in Australia said they found it easier to travel to their optometrist than visit the Royal Victorian Eye and Ear Hospital in Melbourne for specialist care.⁸ Patients in the Bristol study cited above reported high satisfaction with their wait times, travel times, and amount of time spent with their practitioner.⁶

There are also supporting data from other situations in which the use of non-MD providers is the norm. A survey of patients asking about experiences with physician assistants

and nurse practitioners reported that approximately half said they would choose these two types of caregivers for their primary care needs. Results were more favorable as patients' exposure to these caregivers increased. Notably, respondents to the survey reported shorter wait times, more accessibility, lower costs, high comfort levels, and more compassionate care with the non-MD caregivers.²

Decreasing wait times may have particularly important implications for outcomes in glaucoma patients. One study found a correlation between low waiting room times and adherence to prescription requirements.⁹ There are other potential advantages as well, including increase in patient volume, improved access to glaucoma specialty care for those who need it, decreased patient travel times, and greater cost-effectiveness.

CONCLUSIONS

To speak personally for a moment, collaborative glaucoma care has allowed me to serve patients using the full extent of my training. My previous experience with low vision rehabilitation, ocular disease, and contact lenses has proved to be valuable in numerous patient encounters. And I have found that having two practitioners with different approaches and mindsets working on the same problem often leads to beneficial results.

I enjoy the unique challenge of managing glaucoma, and I find it very rewarding to help patients maintain their vision and

their quality of life. With regard to measuring outcomes, professional satisfaction is important, as it breeds greater engagement with patients. The collaborative model of glaucoma is one that can enhance the delivery of patient care and benefit the institution, the providers, the payers, and the patients. ■

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ASSESSING CORNEAL BIOMECHANICS

The importance of these properties rests primarily with their effects on IOP measurement.

BY LEON W. HERNDON, MD



Glaucoma can be defined as a progressive optic neuropathy, with characteristic morphologic changes of the optic nerve head and nerve fiber layer. Elevated IOP is the major modifiable risk factor for the development¹ and progression² of the disease. The Goldmann applanation tonometer is currently the gold standard for measuring IOP. In first describing their applan-

ation tonometer, Goldmann and Schmidt discussed the effect of central corneal thickness (CCT) on IOP as measured by the new device.³ They felt that variations in corneal thickness occurred rarely in the absence of corneal disease but acknowledged that, at least theoretically, CCT might influence applanation readings. It has since become apparent that CCT is more variable among clinically healthy patients than Goldmann and Schmidt ever realized.

Studies by Von Bahr showed large variations in CCT within a healthy population,^{4,5} and research by Ehlers and coworkers demonstrated that this variation in CCT had an effect on applanation-measured IOP.² Many studies have since looked at the influence of CCT on IOP measurement, with most agreeing that measured IOP rises as CCT increases.⁶ CCT alone, however, accounts for only a small proportion of the interindividual variation in measured IOP.

CORNEAL HYSTERESIS

Goldmann applanation tonometry measures IOP by flattening the cornea, which is not neutral in this measurement. Liu and Roberts showed that factors affecting corneal resistance include structural considerations such as the amount of rigidity produced by the way the collagen beams in the tissue line up.⁷ The “bendability” of corneal tissue can also be affected by short-term factors such as the presence of corneal edema.

The Ocular Response Analyzer (ORA; Reichert) measures the corneal response to indentation by a rapid air pulse. The principles of the instrument are based on those of noncontact tonometry: the IOP is determined by the air pressure required to applanate the central cornea. The ORA takes two measurements of the corneal response to the pulse of air: the force required to flatten the cornea as the air pressure rises (force-in applanation, P1) and the force at which the cornea becomes flat again as the air pressure falls (force-out applanation, P2). The difference between the two pressures is termed *corneal hysteresis* (CH).

CH is a direct measure of the cornea’s biomechanical properties and may more completely describe the contribution of corneal resistance to IOP measurements than CCT alone.⁸ There are

“ [Central corneal thickness] alone ... accounts for only a small proportion of the interindividual variation in measured IOP.”

now several hundred publications on the subject, many of which validate and support the use of CH in glaucoma care. Among the first studies to demonstrate the clinical utility of CH as a risk factor for glaucoma was a retrospective report of 230 glaucoma patients and suspects.⁹ The goal of the research was to identify associations with progression. A lower CH was more associated with progressive visual field loss in this study than was a lower CCT.

CH has also been associated with the risk of progression in patients with normal-tension glaucoma (NTG). A retrospective study of 82 eyes being treated for NTG included an assessment of CH.¹⁰ The study sample was then divided into two groups: those with CH higher than the mean and those with CH lower than the mean. The risk of NTG progression was 67% in the eyes with low CH and only 35% in the eyes with high CH. In a multivariate model of visual field progression, CH was highly predictive, whereas CCT was not significantly predictive at all. This study demonstrated that CH can be used independently of IOP



WATCH IT NOW

Nathaniel Radcliffe, MD, discusses the complex relationship between glaucoma and corneal hysteresis.



AT A GLANCE

- Corneal hysteresis (CH) is a direct measure of the cornea’s biomechanical properties and may more completely describe the contribution of corneal resistance to IOP measurements than central corneal thickness alone.
- Researchers found that a lower CH was more associated with progressive visual field loss than was a lower central corneal thickness. In another study, CH was associated with the risk of progression in patients with normal-tension glaucoma.
- A prospective crossover study suggested that CH may at least partly explain asymmetry in primary open-angle glaucoma.
- Differences in corneal biomechanics may indicate more generalized structural differences between eyes.

“ It has only recently become possible to measure the biomechanical properties of the cornea in vivo.”

and CCT as a prognostic factor for glaucomatous progression.

Asymmetry in primary open-angle glaucoma may also be explained, at least in part, by CH. In a prospective crossover study, investigators observed 117 patients with asymmetric primary open-angle glaucoma.¹¹ Among several factors evaluated as having a potential association with asymmetry of glaucoma severity, CH offered the best discriminative power for discerning the worse eye.

STRUCTURAL DIFFERENCES

It is possible that differences in corneal biomechanics indicate more generalized structural differences between eyes. Wells et al assessed healthy and glaucomatous eyes for the relationship between (1) acute IOP-induced optic nerve head deformation and (2) CH and CCT.¹² The investigators found that, in glaucoma patients, CH but not CCT was associated with increased deformation of the optic nerve's surface during transient elevations in IOP. That this finding did not hold true in control patients suggests that glaucoma may modify the biomechanical properties of tissues supporting the optic nerve head.

CONCLUSION

It has only recently become possible to measure the biomechanical properties of the cornea in vivo, and the importance of these properties rests primarily with their effects on IOP measurement. Corneal biomechanics, however, may provide an indication of the structural integrity of the optic nerve head. Further work is required to determine precisely how clinicians may be able to risk stratify glaucoma patients based on their biomechanical properties. ■

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