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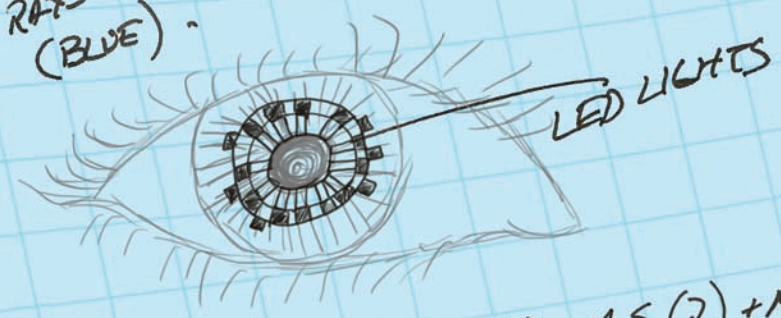
Review of Cornea & Contact Lenses

OCTOBER 2012



$$S_D(\lambda) = [S_0(\lambda) + M_D S_1(\lambda) + M'_D S_2(\lambda)$$

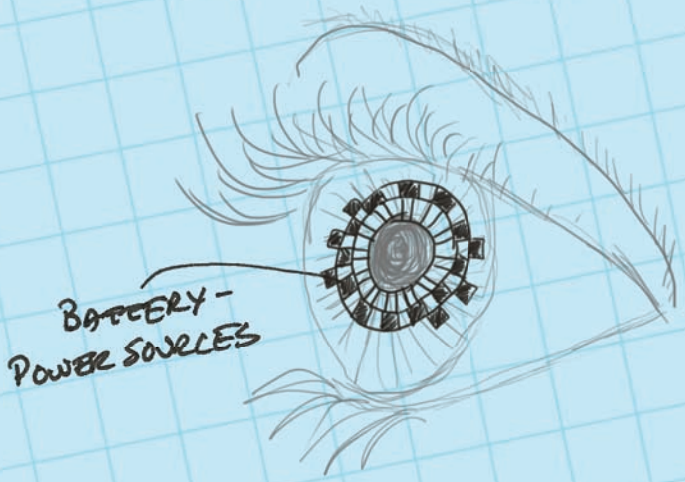
$$f_D K_M \int_{360nm}^{780nm} V(\lambda) S_D(\lambda) d\lambda = E_D$$

TECHNOLOGY

A BLUEPRINT OF TOMORROW'S SMART LENS

ALSO INSIDE THIS ISSUE:

- OSD Treatment Goes High Tech
- CE: Can You Spot These Dry Eye Imposters?
- 10 Tips for Smarter Scleral Lens Fitting
- Tech Treatments for the Thinning Cornea



$$G_D = \int V(\lambda) S_D(\lambda) d\lambda = \frac{E_D}{K_M f_D} = 92.1$$

Supplement to REVIEW® OF OPTOMETRY

October 2012

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There's a reason we're called DAILIES® AquaComfort Plus®. Give your patients comfort **plus** so much more for about the same price as ACUVUE^ OASYS^.[2]

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†Based on a survey of 1,654 contact lens wearers in the US.
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References: 1. Based on third party industry report MAT June 2012, based on unit sales, Alcon data on file. **2.** Based on typical rebates and compliance with manufacturer-recommended lens replacement for DAILIES® AquaComfort Plus® and ACUVUE^ OASYS^, and lens care for ACUVUE^ OASYS^; Alcon data on file, 2012. **3.** Dumbleton K, Woods C, Jones L, et al. Patient and practitioner compliance with silicone hydrogel and daily disposable lens replacement in the United States. *Eye Contact Lens.* 2009;35(4):161-174. **4.** Alcon data on file, 2012.

See product instructions for complete wear, care, and safety information. Rx only

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contents

Review of Cornea & Contact Lenses | October 2012

Technology Issue

ON THE COVER

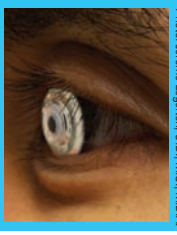
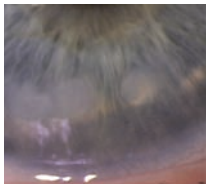
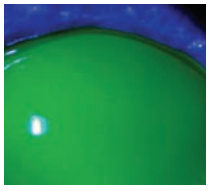
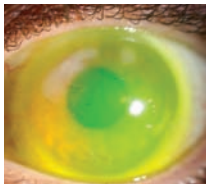


Photo: Jerome Legerton, O.D., M.S., M.B.A.







Departments

VOL. 149, No. 7

In The News

• The **American Board of Optometry** has added new test dates to its winter examination window. The exams will now begin on December 10, 2012 and run through January 20, 2013. Registration is now open and applications for Active Candidacy will be accepted on a rolling admission. Also note that the application deadline for the phase-in rules inclusion is April 30, 2013. For more information, visit www.americanboardofoptometry.org.

• ***Healthy Vision & Contact Lenses*** is a new, web-based education resource for practitioners to share with their patients either in-office, on the web or via social media. The website, also available in PDF and print versions, offers tips for handling and wearing contact lenses, easy-to-follow steps to reduce contact lens-related infections, and information about proper use and care for lenses, according to Vistakon. For more information, visit www.acuvueprofessional.com/hvcl.

• The **British Contact Lens Association** (BCLA) is accepting applications and nominations for its 2014 research awards through November 1, 2012. The **BLCA Medal Award** goes to an individual who has made an outstanding contribution to contact lenses. The **BCLA Dallos Award** funds a year-long project that will further understanding of a topic related to contact lenses and/or the anterior eye. The **BCLA Da Vinci Award** recognizes work by those not established as contact lens researchers. Finally, one postgraduate in the field of contact lenses and/or the anterior eye will be selected to present the annual **Irving Fatt Memorial Lecture**. For more information, visit www.bcla.org.uk.

Fellows of IACLE Exam Announced

Interested in adding "Fellow of the International Association of Contact Lens Educators" (FIACLE) to your title? If so, take note that IACLE is now accepting applications for its 2013 fellowship. The fellowship exam is held every two years; the next will take place in November 2013. All IACLE members are eligible to sit for the exam, but must serve 12 months prior to becoming a fellow. Therefore, new members who join by November 30, 2012 will be eligible for the fellowship.

There are two types of memberships at the IACLE: *educator membership* is open to all involved in contact lens education at a recognized institution, while *associate membership* is open to individuals and industry representatives who contribute to education and are active in IACLE.

For more information, visit www.iacle.org.

Besivance Adds New Indications

The FDA has granted four additional labeling indications for Besivance (besifloxacin ophthalmic suspension 0.6%, Bausch + Lomb). The eye drop now has an indication to treat bacterial conjunctivitis infections caused by susceptible isolates of *Pseudomonas aeruginosa, Aerococcus viridans*, *Moraxella catarrhalis* and *Staphylococcus warneri*.

Since 2009, Besivance has been approved in the United States for the treatment of bacterial conjunctivitis. According to the company, it is the first and only dual-halogenated chlorofluoroquinolone in topical ophthalmic use, which is believed to better inhibits bacterial DNA replication.

For more information, visit www.bausch.com.

OcuSoft Launches Kid Formulation

For practitioners and caregivers alike, a new specially formulated gentle eyelid and eyelash cleaner for children of all ages is now available. OcuBaby is a mild, tear-less formula designed to remove irritants and debris that may contribute to blocked tear ducts, pink eye, allergies and other eyelid-related conditions in infants and small children. The formulation contains no parabens, fragrances, dyes or quaternium-15. According to OcuSoft, the towelette can be used directly on the eyelid and eyelashes with no additional rinsing needed.

OcuBaby is available at Walgreens and Duane Reade pharmacies nationwide.

For more information, visit www.ocusoft.com.

Review of Cornea & Contact Lenses

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PROSE to Treat Severe Dry Eye

Patients with severe dry eye might benefit from a custom-made removable prosthetic device that continuously bathes the eye in artificial tears. Called "prosthetic replacement of the ocular surface ecosystem" (PROSE), the device sits directly on the sclera and is composed of material that allows oxygen to reach the cornea. By creating a smooth surface over the damaged cornea, and through constant lubrication, oxygen is continuously supplied to the cornea. Reports say that the device supports healing and reduces pain and light sensitivity.

PROSE is now available at the University of Michigan Kellogg Eye Center, one of only nine academic medical centers in the country offering this treatment.

Corneal specialist H. Kaz Soong, M.D., said those who benefit from PROSE include patients with severe dry eye, many of whom have undergone bone marrow transplant; patients who have suffered injury to the ocular surface, such as from chemical burns; patients with primary diseases or those who have suffered previous eye injuries; and patients with systemic inflammatory diseases.

For more information, visit www.kellogg.mich.edu.

iDesign Aberrometer in U.S. Clinical Trial

Wavefront-guided LASIK stands to advance in sophistication now that a new device, the iDesign Advanced WaveScan Studio, has recently obtained the European CE Mark and is being studied for use in the U.S. This new diagnostic tool uses high-definition wavefront aberrometry and corneal topography to create custom ablation profiles that correct for corneal or lenticular optical aberrations as well as corneal surface irregularities.

Working with other products in its arsenal, parent company Abbott Medical Optics outlined the new three-step iLASIK process: creating a corneal flap using the iFS femtosecond laser, using the iDesign to draw up a treatment plan, and executing it through the Star S4 IR Excimer laser system for a computer-driven laser correction.

AMO has recently started clinical trials for the iDesign aberrometer in the United States.

For more information, visit www.abbottmedicaloptics.com.

Advertiser Index

Editorial

By Joseph P. Shovlin, O.D.

Small Changes, Big Payoff

Suggest a few positive lifestyle improvements and see a healthier, happier patient.

Discussing lifestyle changes in healthcare journals is not new. For years, practitioners have touted the value of making simple, daily adjustments to enhance one's personal quality of life and longevity. Even the healthcare industry is starting to value how positive daily life improvements can help prevent disease, which—in turn—will reduce our rising healthcare costs.

An individual's lifestyle choices impact all disciplines in healthcare, including eye care. Sometimes, a patient may visit us for routine care, but we see that they are in serious need of a lifestyle change. By recommending improvements to one's daily routine, our contact lens wearers may be able to increase lens comfort and improve safety and efficacy, while simultaneously addressing modifiable risk factors for disease. Smoking cessation, losing weight through increased exercise, healthier eating and reducing stress are just a few examples of changes to incorporate into an everyday routine that can pay off monumentally.

A Case in Point

Research indicates that obesity alone is responsible for 20% of cancer diagnoses today.[1] If individuals could maintain a BMI between 21kg/m^2 to 23kg/m^2, the incidence of cancer could be reduced by approximately 50% in two to 20 years. Furthermore, lack of exercise and a poor diet are each estimated to be associated with 5% of all cancers. Fifty percent of these cases likely could be avoided if at-risk patients simply improved their diets.[1] Additionally, increased physical activity levels could dramatically curtail cancer incidence by as much as 85% in five to 20 years, according to Graham Colditz, M.D., Dr.P.H., from the Washington University School of Medicine in St. Louis.[1]

Perhaps you are thinking that this cancer discussion has little to no relevance to eve care. But remember, with our new electronic health records and "meaningful use" requirements, we are now mandated to ask our patients about certain lifestyle behaviors—including smoking.

> *"We have more scientific data on the impact of a healthy lifestyle today than ever before, yet we struggle to effectively convey that message to our patients."*

Also, the aforementioned research pinpointed that one-third of cancer cases in high-income countries is indeed caused by smoking.[1] If smoking rates throughout the United States could be reduced to the current 11% level found in Utah, for example, we could see a 75% reduction in smoking-related cancers in as little as 10 to 20 years.[1] Other proactive lifestyle routines include screenings and use of daily aspirin, vaccinations, vitamin and medicinal regimens, preventive surgery and weight loss.

What resonates the most, however, is Dr. Coldtiz's conclusion that we have more scientific data on the impact of a healthy lifestyle today than ever before, yet we struggle to effectively convey that message to our patients.

As eye care practitioners, we often wonder whether asking questions about a patient's lifestyle during an exam is warranted. I believe Dr. Colditz's research stresses that any discussion we may have to encourage or teach a patient about healthier lifestyle choices will indeed pay dividends. Keep in mind, though, that often the patient who would benefit the most from positive lifestyle changes is the one most reluctant to make the necessary adjustments.[2]

Continue to educate, monitor behavior and reinforce your recommendations at every exam. I challenge all eye care practitioners—myself included—to do our part to enhance longevity, improve quality of life and reduce increasing costs on our healthcare system. And while we're at it, let's be sure to follow our own advice and lead by example. RCCL

1. Harrison P. Lifestyle changes could prevent 50% of common cancers. Presented at the Union for International Cancer Control (UICC) World Cancer Congress meeting, August 27-30, 2012; Montreal, Canada.
2. Ulene V. Why are unhealthy people so reluctant to change their life? LA Times. 2011 May 23. Available at: http://articles.latimes.com/2011/may/23/health/la-he-the-md-change-illness-20110523. Accessed September 2012.


By Jill Autry, R.Ph., O.D., and Elyse Chaglasian, O.D.

Retiring the Prescription Pad

If you haven't already, consider incorporating electronic prescribing into your practice.

As a former pharmacist and a current prescriber, Dr. Autry has the unique opportunity to speak from both sides of the counter regarding electronic prescribing. She remembers holding one phone to each ear, simultaneously on hold with a physician's office to verify an illegible drug dosage and an insurance company to confirm that an ordered medication was on the formulary plan.

Pharmacists tend to view electronic prescribing as something of a godsend. Less time spent on the phone to clarify vague or illegible prescriptions means more time to counsel patients or work more productively. Eye care practitioners also see the advantages, but a few disadvantages as well.

In keeping with this issue's focus on technology, we offer a status update on the current trends in electronic prescription writing, better known as e-prescribing.

A Little History

Primitive forms of e-prescribing via computer-aided physician-order entry originally appeared in a handful of hospitals in the late 1970s and early 1980s.[2] It was the Centers for Medicare and Medicaid Services (CMS), however, that enhanced discussion, interest and participation in e-prescribing by making it a part of the Medicare Modernization Act of 2003.[1]

With the shift from inpatient to outpatient care, the Institute of Medicine reports that medication errors are increasing and are already responsible for thousands of deaths yearly in the United States. The advantage of e-prescribing is clear: it decreases medication errors and increases patient safety.[3,4] Because the prescriber has instant access to the patient's full medication profile, he or she can avoid drug duplication, allergy errors and/or drug interactions at the time of prescribing.

Pharmacists cannot misinterpret the prescription because of illegible handwriting or oral miscommunication, which currently results in about 30% of callbacks.[4] Lastly, drug strength, dosage, instructions, drug-disease and drug-drug interactions are cross-checked immediately with pharmacy software programs. In addition, e-prescribing can improve office productivity by decreasing patient and pharmacy refill requests and save time for patients by eliminating drop-off and pick-up wait times.

Understanding E-prescribing

There are two main types of e-prescribing systems: standalone options and systems that operate in conjunction with an EMR system. Doctors who are not ready to completely switch to EMR can still participate in e-prescribing by registering with the National e-Prescribing Patient Safety Initiative (NEPSI) and participating through various free web-based electronic prescribing vendors such as Allscripts (www.allscripts.com), Practice Fusion (www.practicefusion.com/e-Prescribing) or ECP Resources (www.revoptom.com).

Seventy-seven percent of physicians who e-prescribe use an EMR system that automatically incorporates an eRx program.[5] An EMR system can essentially render an office paperless, and hard-copy prescriptions are one of the easiest items to dispense with first. Doctors should take heed to verify the EMR program is eRx compliant when investing in a new system.

Given its obvious advantages, e-prescribing is becoming more common. Surescripts, the country's largest electronic prescribing network company, reports an encouraging 400% increase in adoption since 2008; the data, however, suggests only 36% of all outpatient prescriptions in the U.S. were electronically prescribed in 2011.[6]

Various factors influence those prescribers who choose to avoid or underuse electronic submission: cost of system implementation (when associated with EMR implementation), cumbersome and extraneous data entry and retrieval, impact on current workflow, and incomplete insurance and/or pharmacy information making electronic prescribing time consuming and sometimes inaccurate. It was found that older practitioners, doctors in solo practices and medical/surgical specialty

(continued on pg. 9)

By Jason Jedlicka, O.D.

Whorl Whorl, Twists and Twirls

When treating corneal epitheliopathies, consider using scleral lenses.

Corneal epitheliopathies can be complicated to manage, since they arise from a multitude of different causes that are often difficult to resolve. Many times, the pattern of the affected cornea can help make the diagnosis, though some atypical presentations can be confounding. Symptoms of corneal epitheliopathies can include grittiness, burning, dryness, watering, photophobia and blurry vision. Therapeutic options include lubricants, Restasis (cyclosporine, Allergan), topical steroids, punctal occlusion, contact lenses, tarsorrhaphy and limbal stem cell transplants.

Scleral lenses, an increasingly popular treatment option, can benefit patients with chronic corneal epitheliopathy and related symptoms by keeping the fluid reservoir in contact with the corneal surface, and by providing the superior optics of gas-permeable lenses for vision correction. This month's column spotlights a case in which an unusual type of corneal epitheliopathy defies other treatment options but benefits greatly from a scleral GP lens.

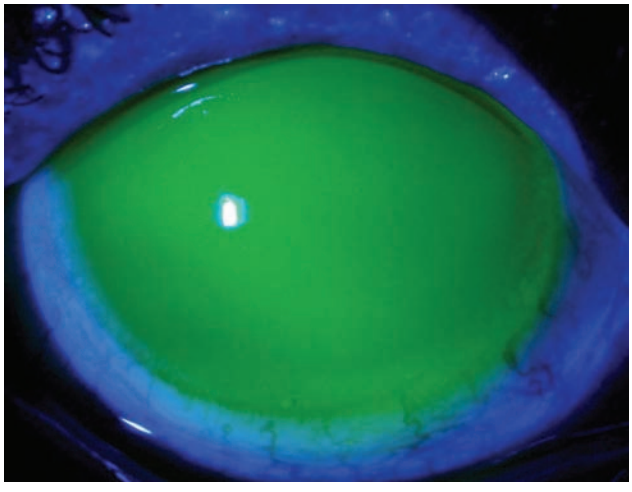
A Case Study

A 37-year-old black male was referred for a contact lens fitting by his corneal specialist. He had previously seen several eye care providers for symptoms of photophobia, blurry vision and chronic irritation. Over the course of these visits, he had been diagnosed with dry eye and treated with lubricants, Restasis, punctal occlusion and topical steroids. All of these treatments had provided only minimal improvement; he still suffered, and continued to wear sunglasses indoors and two pairs of sunglasses when outside. His vision had deteriorated to the point that he felt unsafe driving.

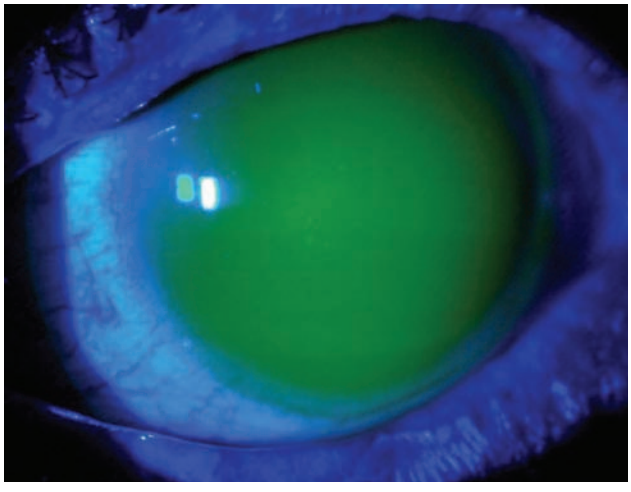
The corneal specialist had diagnosed him with a corneal epitheliopathy; however, at this time the specific etiology was undetermined. Prior to any surgical intervention, it was recommended that he consider scleral lenses.

At examination, his uncorrected acuity was 20/60 O.U. A refraction did not improve his vision. Slit lamp exam revealed 2+ bulbar conjunctival and limbal injection, and 2 to 3+ whorl-like corneal staining. Within the densest areas of staining, there were small, elevated concentrations of epithelium. The palpebral conjunctiva was also 2+ injected O.U., but all other internal and external finding were normal.

After discussing his options, the patient consented to a trial of scleral lenses. A lens was placed on each eye and he could report some immediate improvement in his ocular comfort. With an overrefraction, he was capable of seeing nearly 20/20 in each eye. He was fitted and the following Jupiter



1a. Scleral lens fit O.D.



1b. Scleral Lens fit O.S.

lenses in Boston XO material with standard peripheral curves were ordered: 46.00mm base curve, -1.75D power and 15.6mm diameter O.D.; 46.00mm base curve, -2.00D power and 15.6mm diameter O.S.

Analysis

The reason for this particular choice of lenses was twofold. First, because of his chronic photophobia and sensitive eyes, it would have been difficult to use a lens with a larger diameter. The Jupiter design on an essentially normal corneal shape would provide a good tear reservoir centrally, where the bulk of the epitheliopathy was located.

Secondly, the lens fit provided full corneal vaulting and good centration (*figures 1a and 1b*). The visual acuity with the lenses was 20/20 in each eye. The patient still reported a degree of photosensitivity, but the feeling of irritation was alleviated and he was generally pleased with the comfort and thrilled with his vision. He was able to function indoors without sunglasses, and outdoors with just one pair. He continues to wear the lenses full time.

Whorl-like corneal epitheliopathy can be seen in patients with certain specific systemic diseases such as incontinentia pigmenti, keratoconus with GP lens wear, limbal stem cell deficiencies or post-penetrating keratoplasty.[1-3] Depending on the severity of the epithelial disease, a variety of therapies can be effective. In many cases, however, vision can be restored, improvements in the health of the epithelium and symptomatic relief can all be achieved with the simple use of a scleral GP lens.[4] RCCL

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2. Somodi S, Hahnel C, Slowik C, et al. Confocal in vivo microscopy and confocal laser-scanning fluorescence microscopy in keratoconus. Ger J Ophthalmol. 1996 Nov;5(6):518-25.
3. Ozbek Z, Raber IM. Successful management of aniridic ocular surface disease with long-term bandage contact lens wear. Cornea. 2006 Feb;25(2):245-7.
4. Rosenthal P, Croteau A. Fluid-ventilated, gas-permeable scleral contact lens is an effective option for managing severe ocular surface disease and many corneal disorders that would otherwise require penetrating keratoplasty. Eye Contact Lens. 2005 May;31(3):130-4.

(continued from **Down on the Pharm,** *pg. 7)*

physicians were also less likely to use e-prescribing when compared to younger practitioners, doctors in group or HMO settings and general physicians, respectively.[6]

Improvements in software are helping to ease the transition, however, and even legislation is catching up with prescribing. This year, various electronic vendors have implemented the DEA's 2010 requirements, which paved the way for controlled substance prescriptions to be transmitted electronically and removed another barrier to the 20% of prescriptions that are for narcotics and other controlled medications.

Government incentives for meaningful use and subsequent penalties for non-use have been instrumental in driving adoption of electronic prescribing. Those who met CMS criteria for successful e-prescribers in the first half of 2012 will receive 100% of their earned Medicare reimbursements for 2013.[7] Those who did not meet the necessary numbers in the first six months of this year will take a 1.5% hit on their Medicare 2013 payments.

If you have yet to become fluent in the world of e-prescribing, you cannot wait any longer. The requirements to be a 2013 successful prescriber are not final, but expect an increase in the number of required scripts; the resultant 2014 penalty of Medicare reimbursements is 2%.[7] RCCL

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By Mile Brujic, O.D., and Jason Miller, O.D., M.B.A.

The Stereopsis Solution

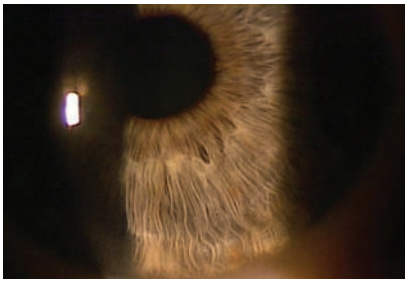
Contact lens failure may not stem from the lenses themselves. But perhaps the remedy can.

Contact lenses offer a remarkable opportunity for our patients to be free of spectacles and see just as well, if not better. However, no great invention is without its challenges. We are often confronted by patients with contact lens intolerance issues due to a number of factors, including poor compliance, inadequate surface wettability and limitations in lens design.[1,2] Underlying ocular surface disease may also play a factor in degrading the quality of the wearing experience through increased lens awareness.

At times, we struggle to meet the visual needs of our patients. Although we have a number of lens options available today, including torics and multifocals, we still occasionally run into situations where contact lenses are not addressing the patient's visual concerns or the fit doesn't seem to be optimal. Surprisingly, these same patients may have appeared to be good candidates on paper based on refraction, ocular anatomy, ocular surface physiology and expectations, but somehow—optically—the experience falls short of expectations.

The Missing Link?

When patients for whom we had expected success fail to achieve acceptable vision in the suggested lenses, we may need to consider that binocular issues may be hindering the ultimate visual potential. Although we tend to measure vertical phorias either during the refraction or with other specialized equipment during the exam, very rarely do we take these findings into consideration with contact lens wearers. In fact, most times, we try to avoid these issues by simply attempting to fit contact lenses without consideration for the phoria and instead wait to observe the patient's response.



1. A prism ballasted lens on the patient's right eye without any astigmatic correction. Note the small marker at the 6 o'clock position.

2. The lens over the left eye contains no prism ballast, as evidenced by no markings on the lens inferiorly.

Certainly, some patients may benefit from vision therapy—in particular those with significant horizontal phorias secondary to convergence insufficiency. Vertical phorias respond remarkably well to the introduction of a vertical prism, so that the base is oriented in the opposite direction of the phoria deviation.[3] If the patient has a right hyperphoria, the introduction of base down prism may alleviate some of the subjective visual symptoms the patient is noticing. Consequently, this allows the eye to assume its natural posture without the need to compensate and attempt to vertically align with the other eye. If this could be done with a contact lens, it may alleviate the problem.

Prism in a Contact Lens

Fortunately, we have a soft toric lens design that features a base down prism through a ballast system. The prism ballast is used to stabilize the lens for the toric prescription. But, can we leverage this technology to help those patients who require vertical prism?

While it would seem feasible to introduce this prism in a contact lens, in order for the patient to appreciate it, there would have to be a difference in the prism magnitude between the right and left eye. Additionally, there would have to be adequate movement of the eye behind the contact lens to align with the new image position altered by the prism.

Knowing this, we should be able to treat a patient who requires low amounts of vertical prism through a prism ballast. Keep in mind, there are certainly limitations to the amount of prism that can be delivered to the eye; usually 1.75 prism diopters is the maximum amount of prism ballast used in a specialty

soft contact lens. Also, only base down prism can be delivered through a contact lens, which means introducing the prism ballast on the eye with the hyperphoria.

As the following case illustrates, sometimes providing unique visual correction options ultimately will provide your patients with the best clinical outcomes.

A Case Study

A 55-year-old white female presented to our office for a comprehensive examination. At that time, her chief complaint was decreased near vision with her current multifocal contact lenses. Her best-corrected visual acuity measured 20/20 O.D. with a +1.25 -0.25D x 010 manifest refraction, and 20/20 O.S. with a +1.25 -0.50D x 105 manifest refraction and a +2.00D add. Binocular status was remarkable for a small hyperphoria O.D. of 2.00 prism diopters, measured through Von Graefe technique. When the prism was demonstrated to her in free space over her best-corrected distance vision in a trial frame, she preferred the vision without any vertical prism. Anterior and posterior segment health was normal.

She was fit with a center near aspheric simultaneous multifocal contact lens design. She did well at the initial fitting and follow-up visit, and continued wearing the lenses. Approximately six months later, she came back to the office with a complaint of decreased distance vision. A trial lens spherical over-refraction was performed in free space, and there were no lenses that improved her vision. When a 1.00 prism diopter base down lens was placed in front of the right eye, the patient responded subjectively with improved vision. However, when a 2.00 prism diopters base down lens was placed in front of the right eye it blurred her vision.

Through a specialty lens laboratory (Unilens), we ordered the patient a near center aspheric multifocal trial lens with +1.25D distance prescription and a +1.75D add O.U. Even though the patient didn't have any astigmatism, the right lens was created with a prism ballast of 1.25 prism diopters in an attempt to deliver base down prism. The patient was dispensed the lenses and the initial visual response was overwhelmingly positive.

In an attempt to determine whether the intended prismatic power was being delivered to the right eye, a one prism diopter base down loose lens was held over the right eye first and then the left eye. When held over either eye, it made the vision blurrier than without the lens, which confirmed that the prism ballast was delivering sufficient prism.

A little over a week later, the patient was seen for follow-up and noted that the vision (both distance and near) was "great" through the new lenses. Although the right lens was not a toric, added prism ballast delivered the required vertical prism for the patient.

Most specialty soft contact lens manufacturers would likely be able to create a lens with a prism ballast.

The take-home message from this case: When all else fails, thinking outside of the box can deliver an improved wearing experience and successfully keep patients in their lenses. RCCL

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By Mark B. Abelson, M.D., C.M., and James McLaughlin, Ph.D.

Seeing the Future of Ocular Imaging

The latest imaging technology can help eye care practitioners better assess and treat corneal complications.

New techniques and advances in imaging technologies have been a topic of great interest as of late, particularly improvements in optical coherence tomography (OCT) and confocal microscopy (CM) for the anterior segment. Of course, one key consideration for any new technology is its clinical practicality. This month, we'll unravel the intricacies of these technologies, and consider how they are being employed as tools for both patient care and clinical research.

Optical Coherence Tomography

The OCT of today comes in two basic formats: time-domain (TD-OCT) and spectral domain (SD-OCT). TD-OCT employs a technology that captures image scans serially according to depth, and uses them to reconstruct an image of the scanned tissue. On the other hand, SD-OCT separates reflective signals according to wavelength, and can collect scans for subsequent tissue re-construction in parallel. The result of these distinctions is that SD-OCT devices can collect scans as much as 100 times faster than TD-OCT devices, thus allowing for greatly improved image clarity and detail.[1] Because the overall design of the SD-based devices is simpler, they also are generally less expensive.

Though traditionally used for vitreoretinal evaluation, recent OCT advancements allow for anterior segment imaging as well. An example of an emerging application for OCT is in the diagnosis of keratoconus. In its early stages, keratoconus can often go undetected. OCT has the ability to identify those individuals with early corneal thinning or other changes in corneal shape.[2] Detection before the appearance of significant changes—including alterations in visual acuity—can allow for early intervention, and also can help identify patients who may be at greater risk for complications from LASIK surgery. By comparing images captured over time, it is possible to follow the progression of corneal thinning with measures comparable or superior to more traditional ultrasound pachymetry.

One of the newer experimental applications of OCT is in dry eye assessment, where it can be used to measure tear film volume by means of tear meniscus height.[3] The noninvasive nature of OCT confers a substantial advantage over other tear film assessments. Schirmer's testing and most other methods of evaluation are disruptive to the ocular surface, potentially skewing the results. Not so with OCT.

In addition, treatment protocols for other anterior segment conditions—such as corneal scars or dystrophies, corneal transplants and anterior segment malignancies—have all benefitted from advances in OCT imaging technologies.

OCT also has become an essential tool in anterior chamber biometry, whether used to help better fit IOLs or to obtain more accurate angle measurements. Unlike ultrasound-based methods, there is no need for direct contact with the ocular surface using OCT. These measures are completed very rapidly, minimizing motion artifacts.

Confocal Microscopy

While the use of OCT for imaging the retina and anterior segment continues to expand, another methodology—confocal microscopy—has also made the move from the back to the front of the eye, becoming a standard technique for assessment of the conjunctival and corneal surface.[4] CM employs standard light sources to image the cornea, or uses laser scanning technology (similar to that used for retinal imaging) to view the cornea, conjunctiva, lid margins and lacrimal glands. This noninvasive, high-resolution imaging can be used to identify and track ocular infections, assess corneal defects and monitor epithelial health in conditions, such as dry eye or chronic allergy.

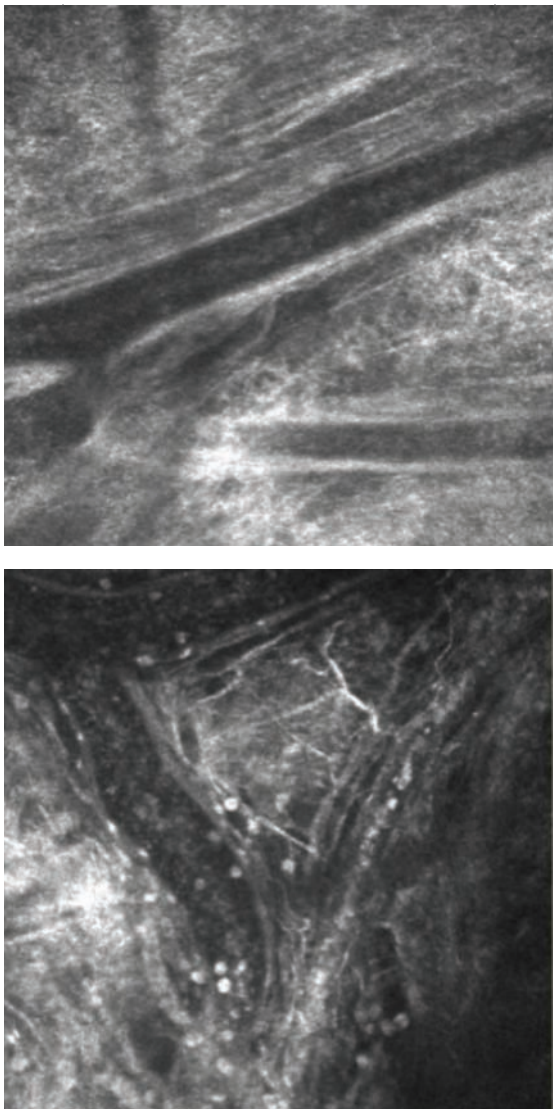
When compared to traditional slit lamp imaging, confocal microscopes can provide a higher magnification and depth of view, which allows for visual diagnosis of conditions caused by *Acanthamoeba* or *Fusarium* infections. This is significant because diagnostic confirmation via culturing can take several weeks. CM also can be used to assess and monitor therapeutic efficacy for these and other infections, such as herpes keratitis.[5]

Looking Ahead

Several recent studies have explored the use of corneal imaging with CM as a means to

track and diagnose diabetic retinopathy by longitudinal assessment of corneal nerve morphology.[6] A number of these reports have been able to correlate changes in the corneal nerve fibers with other metrics of diabetic neuropathy such as quantitative sensory testing and nerve conduction velocities. At the same time, these studies highlight a major challenge in the use of CM for research: There is a need for more reliable methods to capture images of the same regions of the ocular surface—especially when studies involve dynamic events, such as changes in nerve morphology or inflammation.

The use of CM imaging has become particularly useful in studies of new treatments for ocular surface disorders. The real-time aspect of this imaging allows researchers to directly assess the efficacy of new therapies in terms of macrophage and lymphocyte infiltration into the conjunctiva as well as in measuring changes in epithelial integrity.[7] The ability to track these ocular surface changes likely will pave the way for studies that can help identify the therapies that may be best suited to treat the earliest stages of dry eye and allergic conjunctivitis.



In vivo imaging of conjunctival blood vessels before (top) and after (bottom) allergen challenge. White cells are clearly visible following challenge, and some of these can be see migrating out of vessels into extravascular space.

The very latest technological advancements typically are found in experimental settings, and the same goes for the newest methodologies in assessing and monitoring dry eye disease. Researchers at our company, Ora, Inc., have been addressing the sometimes baffling assortment of metrics used in diagnosing dry eye by focusing on new, objective criteria in combination with patient subpopulation analysis.[8]

One example of this is our computer-based imaging method, which is used to define and track dry eye signs and symptoms.[9] These studies are designed to bring new therapeutics to market. They represent a merging of the best of both worlds in the development of new ocular therapies: the latest in image capture and analysis techniques with more traditional clinical research methods. RCCL

Dr. Abelson is the founder and scientific advisor for Ora, Inc. Dr. McLaughlin is an employee of Ora, Inc.

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By David L. Kading, O.D., and Mile Brujic, O.D.

Consider OPTI-FREE® PureMoist® MPDS to Increase Comfortable Wear Time

As contact lens prescribers, we regularly encounter patients who struggle with comfortable lens wear. In fact, comfort is cited as one of the most important lens attributes that our patients seek.[1] Not only is comfort a critical component for keeping patients satisfied in their lenses, but it also plays a critical role in keeping our patients in their lenses. As we know, discomfort and dryness have repeatedly been reported as the top two reasons why patients discontinue lens wear.[2-8]

OPTI-FREE® PureMoist® MPDS

There are many causes for dryness, including patient's environment, tear film and the lenses themselves. For some patients, wearing silicone hydrogel (SiHy) lenses can reduce the symptoms of dryness. In one study, 29% of young adults wearing soft lenses, compared to only 17% wearing SiHy lenses, reported dryness symptoms.[9]

Keep in mind, though, SiHy lenses—which make up 67% of contact lenses on the market today—are not without challenges.[10] While this is indeed the material of choice for our two-week and one-month wearers, the SiHy lenses have hydrophobic siloxane-containing components, which have been associated with a reduced on-eye-wettability.[11] Clinically, one method to address this issue is to use contact lens solutions that enhance wettability of the lens surface.

OPTI-FREE® PureMoist® MPDS is a contact lens solution that will help contact lenses retain moisture. This MPDS incorporates a specifically designed wetting agent, HydraGlyde® Moisture Matrix (EOBO) technology, a di-block copolymer. One portion of this di-block copolymer is hydrophobic and attaches to hydrophobic contact lens sites. This enables the other hydrophilic portion of the EOBO molecule to attract moisture to the surface.[12] When lenses are soaked in OPTI-FREE® PureMoist® MPDS, the EOBO will embed on the hydrophobic areas of the lens surface to create a more hydrophilic surface.[13-15] As clinicians, however, we like to see this type of evidence challenged with on eye testing.[14,15]

Clinical Trial

One recent study looked at the effects of OPTI-FREE® PureMoist® MPDS on symptomatic patients wearing silicone hydrogel lenses.[12] Looking at 589 patients at 42 sites over the course of 30 days, subjects were evaluated for acceptability and comfort evaluation. Patients wore Acuvue Oasys* (Vistakon), AIR OPTIX® AQUA† (Alcon), Biofinity* (CooperVision) or PureVision* (Bausch + Lomb) lenses. At the initial visit, subjects were asked a series of questions and underwent a thorough slit lamp evaluation.

Following 30 days of use, subjects were questioned on their comfort again. The patients using OPTI-FREE® PureMoist® MPDS reported that their comfortable wear time increased nearly two hours. The authors believe that an improvement in perceived comfort may also help reduce the dropout rate in this population of patients.[12]

By targeting patients who are less than satisfied with their lens wear comfort, and specifically addressing our patients' symptoms, we can recommend the appropriate contact lens solution for them. As seen in the aforementioned study, patients who have problems with their lens wear may be able to achieve nearly two more hours of comfortable wear time by switching to OPTI-FREE® PureMoist® MPDS.

Next month, we will look at how this study data can aid in patient satisfaction and practice growth.

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†AIR OPTIX® AQUA (lotrafilcon B) contact lenses: High oxygen transmissible lenses. Dk/t = 138 @ -3.00D.
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See product instructions for complete wear, care, and safety information.

OSD Treatment Goes High Tech

Advances in diagnostic and therapeutic technology now give us better tools to treat ocular surface disease than ever before.

By Katherine Mastrota, M.S., O.D.

I have had the privilege to author a number of dry eye/ocular surface disease articles in the past, and I am delighted to say that the core science and management concepts have remained fairly constant over the years. What has changed, however, is the availability of cutting-edge diagnostic and therapeutic technologies designed to meet the challenges of OSD. The modern eye care community is now cognizant of the critical role of the ocular surface/tear film in maintaining clear, comfortable vision and is experienced in the rudimentary OSD testing principles of the past. And finally, our tools for managing OSD are starting to match the sophistication of those found elsewhere in eye care.

In this article, I will review our OSD history and discuss how technology has assisted our ability to manage the disease.

Tear Film

It was in 1903 that German ophthalmologist Otto Schirmer invented his namesake test to quantify tear volume/production.[1] That this simple absorbent paper test, developed when Teddy Roosevelt was in the White House, has endured for over a century is testament to its clinical utility. However, in addition to its iatrogenic irritating effect, Schirmer testing has several limitations, including variable results and poor repeatability. These disadvantages remained a limitation of tear testing for eight decades until the phenol red thread test (Zone-Quick, Menicon) was developed by Hikaru Hamano, M.D., in 1982, alleviating—but not completely eliminating—the shortcomings of tear testing.[2]

Today, we have more modern methods than threads and paper strips. Numerous studies suggest an

Dr. Mastrota is Center Director at the New York Office of Omni Eye Services. Additionally, she serves as secretary of the Ocular Surface Society of Optometry (OSSO).

association between tear meniscus height/curvature/volume and dry eye.[3-6]

• ***Optical coherence tomography.*** We now find practitioners successfully using OCT anterior segment modules as a non-invasive, non-contact modality for imaging/quantifying the tear film and tear meniscus.[7] OCT is a quick method for assessing the tear meniscus height, with acceptable sensitivity, specificity and repeatability; thus, it has potential for the diagnosis and evaluation of dry eye disease.[7]

The OCT anterior segment modules image the tear film and tear meniscus height can then be determined from the scan. Although research labs have designed programs to quantify the volume and/or analyze the data differently, there is currently no commercial software available to do so. As a clinician, I would recommend using the lacrimal lake height measure to objectively evaluate the efficacy of DE management (therapeutics/plugs/other therapy) in conjunction with clinical symptom reports.

• ***Oculus Keratograph.*** As an alternative to OCT, the Keratograph corneal topographer (Oculus) can also measure the height of the inferior tear meniscus. In addition, the device can measure tear film break-up time by detecting changes in the instrument-projected placido rings on the cornea and generates a metric that the manufacturer calls the non-invasive keratograph break-up time (NIK-BUT). Oculus suggests that this measure can provide qualitative information on the stability and composition of the tear film by comparing the patient's findings to a normative database.

Intuitively, there seems to be an advantage to NIK-BUT compared to the "one-Mississippi, two-Mississippi" count in slit lamp/fluorescein aided tear break-up measurements. Released in May 2012, the Keratograph 5M, also from Oculus, can generate meibography images of the upper eyelid as comfortably as the lower eyelid—a unique and useful capability. The accompanying 5M software provides options to mark individual examination fields or select between different representations of the meibomian glands.[8]

• ***TearLab Osmolarity System.*** Aside from assessing tear lipid integrity, tear film osmolarity measurement (now available as an in-office test) has been found to be the single best marker of dry eye disease severity across normal, mild/moderate and severe categories, and has been proposed as a biomarker for dry eye disease severity.[9,10]

The more highly concentrated tear film (i.e., increased osmolarity) that results when the quantity or quality of secreted tears is compromised places stress on the corneal epithelium and conjunctiva.[11] Previously, this measure could only be obtained by laboratory processing of a tear sample. The TearLab Osmolarity System uses just 50nl of tear film—easily recovered from the lacrimal lake near the lateral canthus with a hand-held instrument—to quantify tear osmolarity within three seconds.

Meibomian Gland Dysfunction

• ***LipiFlow Thermal Pulsation System.*** Of course, we are also seeing technological advancements in the treatment of MGD. Once relegated to heated, seed-filled socks; warmed, soggy washcloths and shower eyelid massage, MGD therapy has been thoroughly modernized with the LipiFlow Thermal Pulsation System (TearScience). The LipiFlow TPS has been documented to restore meibomian gland function and has been demonstrated to provide relief from symptoms of MGD for as long as 12 months.[12]

With the LipiFlow, both upper and lower eyelids are treated simultaneously. A disposable shell unit (that vaults the cornea) warms the eyelids to the ideal temperature of 42.5°C, after which an outer bladder inflates and deflates. This motion gently "massages" the meibomian glands, evacuating stagnant meibum and encouraging more-normal lipid flow. The 12-minute, bilateral procedure is precisely orchestrated by the device.

LipiFlow TPS has a Category III CPT code of 0207T. As the TPS is considered experimental and investigational by most insurance carriers, the treatment is generally not covered and would be considered a private pay procedure.

• ***Meibomian Gland Evaluator.*** MGE (Tear Science) is a handheld instrument used to evaluate meibomian gland secretions and is useful in determining which patients may benefit from LipiFlow treatment.

According to the manufacturer, the instrument applies consistent, gentle pressure—between 0.8g/mm^2 and 1.2g/mm^2—to the outer skin of the lower eyelid.[13] The clinician uses a slit lamp to look for lipid expression from the meibomian gland orifices to gauge gland patency and production.

• ***LipiView Ocular Surface Interferometer.*** Also from TearScience, this complementary device is used to image the tear film, quantify lipid layer thickness and, importantly, evaluate blink patterns. It does so using broad-spectrum white light interferometry and interferometric color assessment of the tear film by specular reflection.[13]

• ***Maskin Meibomian Gland Intraductal Probes and Tubes.*** Developed by Rhein Medical, these instruments were designed to relieve meibomian gland obstruction and dysfunction.

Meibomian gland duct probing is the process of mechanically unblocking obstructions postulated to occur at the orifice and within the lumen of the meibomian gland.[14]

Meibomian gland probing has been found to improve symptoms and to increase the number of meibomian glands showing expressible meibum.[15] Intraductal tubes can be used to instill medications directly into the meibomian glands.

• ***Maskin Meibum Expressor.*** The MME (Rhein Medical) assists the evacuation meibomian ducts. After probing has restored patency to the meibomian gland orifice, the clinician places the eyelid between the two rollers on the MME device and gently applies tension to clear the ducts. The instrument's inventor, ophthalmologist Steve Maskin, found that it works best when moved perpendicularly from the tarsal base toward the lid margin to push squeeze out ductal contents.[16]

Dr. Maskin's two instruments, used in concert, are designed to relieve meibomian gland ductal obstruction and evacuate the gland outflow tract.

Blepharitis

Another hand-held instrument used to treat blepharitis, specifically *Demodex* blepharitis, is the BlephBrush designed by OcuSoft. The BlephBrush is included in the Demodex Convenience kit, a packaged system to help control *Demodex* overpopulation on the lid margin.

The *Demodex* mite (*Demodex folliculorum* and *Demodex brevis*) is pervasive in human skin and hair. *D. folliculorum* is found in hair follicles, while *D. brevis* lives in sebaceous glands. *Demodex* infestation is associated with recalcitrant symptomatic blepharitis.[17-19]

The BlephBrush is used to apply a proprietary blend, including tea tree oil, which has acaricidal properties, to the lash line and subsequently remove desquamated skin and debris.[20]

Inflammation

Hyperosmolar stress on ocular surface epithelial cells stimulates a cascade of inflammatory events by generating inflammatory cytokines.[21] Another proposed biomarker for dry eye disease is the level of matrix metalloproteinase-9, an inflammatory marker, in the tears. This can be measured in the office using the RPS InflammaDry Detector kit from Rapid Pathogen Screening.

Once a sample is collected, it takes about 10 minutes for the assay to be assembled and a result read. Positive test results suggest that inflammation of the ocular surface must be addressed via anti-inflammatory or immunomodulatory therapy (e.g., topical steroids or cyclosporine).

Similar in nature to the RPS Adeno Detector, I believe that this point-of-care tool will be the first of many possible diagnostic biomarker tests for DED. InflammaDry is not yet available in the United States, although the company has filed with the FDA. It is currently approved in Canada.

This is an exciting time for clinicians managing dry eye and ocular surface disease. New and developing diagnostic and treatment technologies can be engaged to monitor disease progression or therapeutic success. Patient compliance and satisfaction can be enhanced with tangible markers of positive change.

Remember, a healthy ocular surface and robust tear film sets the stage for successful ocular and intraocular surgeries. These technologies have the potential to provide clinical endpoints to determine success of pipeline therapeutics in dry eye disease, which to date, has been an elusive task in drug development. RCCL

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Can You Spot These Dry Eye Imposters?

Many conditions that mimic dry eye symptoms can distract you from the primary goal of restoring a healthy ocular surface. Here's advice on diagnosis and management.

By Blair Lonsberry, M.S., O.D., M.Ed., and Paul M. Karpecki, O.D.

Dry eye is one of the most prevalent ocular diseases today and, in fact, one of the top reasons patients seek eye care. It also is an important public health concern, because the condition can result in the bothersome symptoms of ocular discomfort and visual disturbances. This, in turn, typically interferes with a patient's ability to perform daily living activities and can even result in permanent changes to the ocular surface.

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Dr. Karpecki works in the corneal services and heads the clinical research department at the Koffler Vision Group in Lexington, Ky.

An accurate diagnosis is the first step in the treatment and management of dry eye. However, this can often times be a challenge, as there are several other conditions that present mirroring symptoms and signs. Collectively known as "dry eye distractors," these conditions may include common ocular pathologies, such as recurrent corneal erosions (RCE), floppy eyelid syndrome (FES), blepharitis/meibomian gland dysfunction (MGD), filamentary keratitis, Salzmann's nodular degeneration, mucous fishing syndrome (MFS) and even a generalized asthenopia secondary to binocular vision dysfunction.

In this article, we will provide a detailed overview of various dry eye distractors and better explain their contribution to ocular surface disease.

Recurrent Corneal Erosions

RCEs are reoccurring episodes of spontaneous breakdown, or sloughing, of the epithelial layer of the cornea. This is caused by poor adhesion complexes between the epithelial basement membrane and Bowman's layer. The resulting ultrastructural changes include abnormalities in the epithelial basement membrane,

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defective or absent hemidesmosomes and decreased anchoring fibrils. The majority occur following superficial corneal trauma or in conjunction with anterior basement membrane dystrophy (ABMD).[1-3]

Fingernail injuries are the most common cause of traumatic RCE; other causes include injuries from paper, cardboard, vegetative material, contact lenses, foreign body removal and trauma to the epithelium during LASIK.[1]

The most prevalent symptom of RCE is acute pain upon waking. Other common indications include photophobia, tearing, blurred vision, redness, burning, blepharospasm and foreign body sensation. These symptoms, which can cause great anxiety and lifestyle disruption, tend to recur in regular daily, weekly or monthly cycles.[2]

Most erosions occur in the lower third of the cornea. Investigators believe that RCEs occur in this location because epithelial stem cells derive from the limbus, and healing of central corneal lesions is accomplished by centripetal movement of peripheral epithelial cells.[4] In addition to a frank epithelial defect that stains with sodium fluorescein, we may see epithelial edema, microcysts and poor epithelial attachment in acute cases of RCE. The epithelium may appear as a slightly wavy or irregular area with surrounding edema. Negative fluorescein staining will be seen in the area of loose or elevated epithelium. Perilimbal injection, upper eyelid edema and blepharospasm are possible in severe cases.[2]

An ABMD may be the underlying etiology, which presents with the classic findings of intraepithelial geographic opacities, microcysts and concentric refractile lesions that resemble fingerprints. The use of retroillumination is helpful in viewing the epithelial defects. Negative fluorescein staining may be present in areas where the epithelium is elevated and not adhering well.[1,2]

• ***Treatment.*** The management plan focuses on decreasing symptoms and encouraging regrowth and reanchoring of the epithelium. It is important to warn the patient of the recurrent nature of the condition, and therefore continue treatment for some time after the eye appears to be healed.

Use of a therapeutic soft contact lens may aid in reforming the adhesion complexes. Therapeutic lenses are used in an attempt to protect the epithelium from eyelid trauma during blinking and adhering to the tarsal conjunctiva. The lenses tend to increase patient comfort and decrease the severity and frequency of recurrences, but they do not always prevent recurrences. Typically, Dr. Lonsberry uses a therapeutic lens for about two weeks, and if a corneal exam shows that the issue is resolved, he removes the lens using curved forceps after hydration. If further treatment is necessary, another lens will be used. A recent study outlines the treatment period time to three months, with a lens change every two weeks.[5]

Topical ophthalmic corticosteroids and oral tetracyclines have been shown to decrease the frequency of recurrent corneal erosions by inhibiting matrix metalloproteinase enzymes. Metalloproteinase enzymes, which have an increased concentration and activity in patients with RCE, have been shown to degrade the epithelial basement membrane and anchoring fibrils.[6]

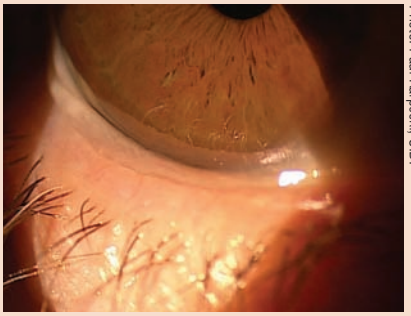


Photo: Paul Karpecki, O.D.

Conjunctivochalasis.

Anterior stromal puncture stimulates the production of collagen and fibronectin, which improve the attachment of the epithelium and basement membrane to the anterior stroma. The scarring from anterior stromal puncture is minimal enough to cause no apparent effect on visual acuity; however, it is typically avoided in the visual axis due to the risk of decreased vision and glare.[7]

For patients who experience RCE on the visual axis, phototherapeutic keratectomy (PTK) has been shown to be an effective treatment to decrease symptoms and increase visual acuity. PTK removes superficial tissue from Bowman's layer in order to allow the formation of a new basement membrane with stronger adhesion complexes.

Superficial keratectomy (SK) with a variable speed diamond burr has also been shown to be safe and effective in treating larger erosion areas and areas that affect the visual axis. No significant difference was found in corneal haze, recurrence of erosions or best-corrected visual acuity in patients treated with SK with diamond burr polishing and patients undergoing PTK. Treatment with a diamond burr, however, is simpler and less expensive.[7,8]

Amniotic membrane used as a graft successfully reduces inflammation and scarring and facilitates

wound healing in persistent corneal epithelial defects caused by a number of ocular surface diseases. Amniotic membrane transplantation (e.g. ProKera from BioTissue) using fibrin glue appears to be a safe and effective method of restoring a stable corneal epithelium for cases with RCE.[9]

Filamentary Keratitis

Filamentary keratitis is defined by characteristic strands of degenerated epithelial cells and mucous attached to the cornea. These corneal filaments can compromise vision and may occur as a complication of various systemic or ocular diseases. Keratoconjunctivitis sicca, or aqueous-deficient dry eye, is the most common cause. Other underlying causes include autoimmune conditions, such as Sjögren's syndrome, complications arising from ocular surgery (cataract surgery, penetrating keratoplasty and photorefractive keratectomy), and allergic reactions to contact lens materials or solutions.[10]

While the prevalence of filamentary keratitis still is undetermined, it is generally considered an uncommon disease. However, with the aging patient population and an increase in dry eye disease presentations, we should be aware that a corresponding increase in filamentary keratitis is possible.[10]

The physiological mechanisms of filament formation remain unclear. It has been hypothesized that damage to the basal layer of the corneal epithelium causes the basement membrane to detach, usually in focal areas. Over time, the blinking action of the lids disrupts the already compromised cornea and raises the epithelial cells.

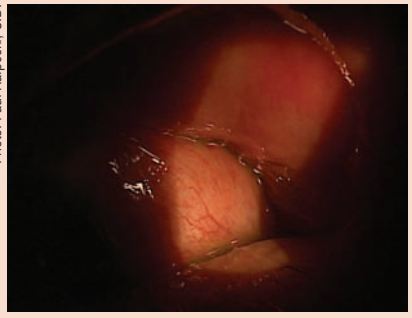


Photo: Paul Karpecki, O.D.

Floppy eyelid syndrome.

Once raised, they serve as receptor sites for mucous and degenerated epithelial cells. This process eventually leads to the creation of corneal filaments, which usually are attached to the cornea on one end and free on the other end.

Friction is created between the upper lid and the filaments upon blink—this leads to epithelial tearing and inflammation, both of which cause pain. Once the inflammatory process has started, further cellular debris and mucous are produced and more filaments are created. A cycle is set in motion: epithelial damage, inflammation, then filament formation.[10,11]

Filamentary keratitis often is seen in conjunction with aqueous-deficient dry eye (ADDE), which presents with ocular surface mucins, ocular surface inflammation, epithelial changes and premature exfoliation of epithelial cells. These changes leave the cornea inflamed, dry and fragile, with the lid interaction on blink more likely to lead to filaments.

ADDE has immense potential for filamentary keratitis. Clinically, it is expected that filaments that are the result of non-autoimmune tear deficiency will be restricted to the interpalpebral zone where the cornea is exposed. It is also expected that autoimmune-related tear deficiency, contact lens use, superior limbic keratoconjunctivitis and exposure keratitis would cause filaments beyond the interpalpebral zone. Autoimmune diseases—specifically Sjögren's syndrome, systemic lupus erythematosus and rheumatoid arthritis—must be ruled out in cases with filamentary keratitis. These conditions may affect the lacrimal gland and cause aqueous deficiency.[10,11]

• ***Treatment.*** The management of filamentary keratitis is challenging. In some cases, lubricants are enough to resolve the filaments, but in these cases, the keratitis is likely to be recurrent and potentially lead to scarring. The common approach here is to tackle the underlying ADDE syndrome.

In some cases, filaments can be removed to provide some relief from the symptoms. Mechanical removal of the filaments is accomplished using forceps or via impression debridement with a cellulose acetate filter. There is some debate as to the usefulness of this procedure, because removing the filaments may cause more epithelial damage and result in slowing of the resolution process.[12]

Artificial tear supplements are a large part of the treatment of dry eye and can play a role in the treatment of filamentary keratitis. Be aware, however, that drops should be preservative free. Drops that stay on the eye longer, such as those with sodium hyaluronate and polyacrylic acid, are also more beneficial. Punctal occlusion can be used to improve tear retention time on the cornea and prevent the corneal surface from becoming damaged.

Anti-inflammatory agents should be used to control the inflammation that is contributing

to the filament formation. This includes both steroidal and non-steroidal agents. In one study, Voltaren (diclofenac sodium 0.1%, Alcon) was applied topically q.i.d. for three to four weeks; within one to two weeks of initial treatment, the filaments had disappeared from the corneas of all patients.[12]

Topical steroids can be beneficial in reducing/snapping the inflammatory cascade that drives the filamentary process. However, doctors are hesitant to treat patients on a long-term basis with steroids in light of their potential complications. The combination of short-term steroidal pulse dosing and long-term administration of an immunomodulator, such as Restasis (cyclosporine, Allergan), has the potential to significantly reduce the inflammatory cycle and increase aqueous production, resulting in a healthier ocular surface.[12]

Therapeutic contact lenses have proven effective, but risk of infections and mechanical trauma must be considered. Contact lenses also may serve as the cause in cases where the tear film is deficient. It is important to treat any concomitant ocular surface problems, such as MGD. Any systemic diseases that contribute to the filamentary keratitis also should be managed—particularly conditions that require systemic medications that may have an effect on the tear film and the ocular surface. Patient counseling is an essential component in the management of this often chronic and recurrent condition.[12]

A novel treatment is the injecting of botulinum toxin into the lids. Eyelid blink results in trauma to the ocular surface, which may result in the development of the cycle of damage and filament development. Relaxation of the orbicularis muscle would be expected to decrease eyelid pressure on the cornea and blink frequency and force. Therefore, ideally the treatment would break the cycle and improve the patient's symptoms.[13]

Blepharitis/Meibomian Gland Dysfunction

Dry eye disease traditionally is divided into two major groups: ADDE and evaporative dry eye (EDE). The latter is a result of excessive evaporation of tears from the ocular surface in the presence of normal secretion from the lacrimal functional unit. EDE can be further broken down into intrinsic and extrinsic causes. Intrinsic causes include MGD, disorders of lid aperture and low blink rate. Extrinsic factors include ocular surface disorders (i.e., from vitamin A deficiency), contact lens wear and ocular surface disease (i.e., allergic conjunctivitis).[14]

In EDE, blepharitis and MGD are the primary lid diseases that contribute to the increased tear film evaporation. The meibomian glands secrete the thin lipid layer that helps prevent the aqueous tear film from evaporating. With each blink, the lids spread the lipid layer over the entire tear film. In patients who have significant lid disease, the production of lipids is disrupted and proper lipid distribution over the tear film is affected. Traditional treatment of lid disease has been lid hygiene, including warm compresses and lid scrubs. Recent evidence has indicated that traditional lid hygiene, as a sole treatment modality, typically is inadequate in restoring the normal function of the meibomian glands.[14]

• ***Treatment.*** Treatment of MGD begins with either a course of systemic oral doxycycline or the initiation of topical azythromycin (AzaSite, Merck Pharmaceuticals)—both off-label uses of the medications—in conjunction with lid hygiene. Both doxycycline and azythromycin possess anti-inflammatory properties that are instrumental in changing the way the meibomian glands produce and secrete their meibum, and have antimicrobial properties to reduce the number of bacteria on the lids. Treatment with these antibiotics helps to restore normal meibum production, which yields a more stable tear film.

Treatment of patients with moderate-to-severe lid disease comprises doxycycline 100mg b.i.d. for three to four weeks, followed by daily administration for the next three months. Some complications with the long-term, high-dose doxycycline use include promoting antibiotic resistance, increased risk of breast cancer and possible development of yeast infections. Low-dose formulations (20mg and 50mg) of doxycycline are available and can be substituted for patients with such concerns. A relatively recent alternative treatment is topical azythromycin, which has been shown to possess similar anti-inflammatory properties, and is recommended with b.i.d. dosing for the first two days and q.d. for a month.[15]

Dietary recommendations include increasing the use of omega-3 fatty acids and reducing the intake of omega-6 fatty acids to help reduce the production of inflammatory mediators, which increases aqueous production and normalizes meibomian gland function. Several studies have demonstrated that the consumption of

oral antioxidants, vitamins and trace minerals significantly increase tear stability. Vitamins A, B1, B2, B6, C and E—with trace elements including calcium, iron and manganese—have been shown to help increase tear film stability in patients with dry eye disease.[16]

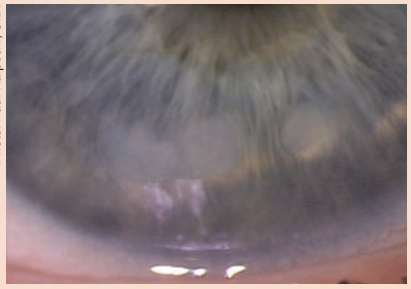
Mucus Fishing Syndrome

MFS is a chronic condition that can lead to a patient extracting (fishing) strands of mucus from their eyes. The syndrome is a cascading cyclic condition in which ocular irritation from conditions such as dry eye, foreign body, keratitis, contact lens-related hypersensitivity and ocular trauma can cause the ocular surface cells to produce excess mucus. The production of excess mucus is irritating to the patient both visually and symptomatically, which often compels the patient to physically extract the mucus from the eye. The removal of the mucus by the patient further irritates the ocular surface through mechanical abrasion and the potential introduction of foreign substances, which ultimately results in further mucus production.[17]

• ***Treatment.*** The condition is often challenging to manage, as the production of mucus can result in strands of several inches in length. Most patients find it difficult to resist attempting to extract these strands, which leads to secondary irritation, blurring of vision and embarrassment.

Conventional management of this condition is to eliminate the underlying irritant to limit the production of the mucus strands. Patient education is also vital: Explain the importance of refraining from extracting the mucus strands when they do appear.

Photo: Paul Karpecki, O.D.



Salzmann's nodular degeneration.

One of the more common underlying etiologies is dry eye, and patients typically have a pre-existing diagnosis of dry eye disease. Treatment of the underlying irritation, such as dry eye, is crucial in the overall treatment of the condition. However, additional agents, such as mucolytic agents (10% to 20% acetylcysteine drops, one to four times daily), reduce the production of mucus, while antihistamine/mast-cell stabilizer agents have been shown to provide marked improvement in patients.[17]

Floppy Eyelid Syndrome

Another condition that often mimics dry eye disease is floppy lid syndrome. Patients with FES often manifest chronic corneal SK, advanced MGD and have symptoms of burning, stinging, irritation and chronic conjunctival injection.

In cases of chronic SK where the patient is non-responsive to therapy, consider FES. The lack of a tight eyelid results in chronic inflammation to the cornea and conjunctiva, which manifests as corneal and conjunctival edema/chemosis and staining. Everting the upper eyelids reveals an extremely "elastic" eyelid, and patients may comment on spontaneous lid eversion. This condition is more common in overweight, middle-aged males.[18] Many patients with FES also suffer from sleep apnea and may be burrowing their eyelids in the pillow.[19]

• ***Treatment.*** Treating the findings may work for mild cases of FES. However, as the condition advances, eyelid tightening surgery is required. It is advisable to maintain the best possible ocular surface with artificial tears, punctal plugs and therapeutics following the procedure to address chronic SK commonly associated with this condition.

Conjunctivochalasis

A relatively common finding, conjunctivochalasis is often mistaken for dry eye. The most common complaints from patients who have conjunctivochalasis or simply chalasis are foreign body sensation and epiphora. In the disease, the Tenon's fascia has loosened or in many cases is absent and the conjunctiva then folds on itself. Patients with chalasis or loose conjunctiva sometimes can pinpoint where the foreign body or pain emanates from—typically where the chalasis or folds are located.

Risk factors for conjunctival chalasis are age (primarily in patients over age 50), a history of dry eye or other inflammatory ocular surface diseases, prior ocular surgery or a history of conjunctival chemosis. Conditions that may cause conjunctival chemosis include long-standing allergic conjunctivitis, trauma or inflammatory conditions such as episcleritis.

Research suggests that a possible association between conjunctivochalasis and immune thyroid disease exists. A 2006 prospective study found that the prevalence of conjunctivochalasis in patients with autoimmune thyroid eye disease was as high as 88%.[20] Therefore, it is imperative to rule

out an association with thyroid disease. Otherwise, systemic management may be initiated by an endocrinologist.

• ***Treatment.*** These patients often are sent over as dry eye patients with "advanced disease" because an inflammatory response is frequently present. In Dr. Karpecki's practice, more than 80% of these cases will require surgical intervention, but it is still worth starting with corticosteroids to see if improvement in signs or symptoms occurs.

The ultimate treatment is surgical in nature. All the surgical procedures involve excising the loose or redundant conjunctiva; the absence of Tenon's fascia requires excising down to the bare sclera. There is variance among surgical technique for conjunctivochalasis, but one of the more common surgical procedures involves excising the loose tissue and then using amniotic membrane tissue over the open area to assist with healing.

The other variance depends on how the conjunctiva is closed. This can be done with sutures that eventually dissolve or need to be removed. More recently, surgeons have been using fibrin tissue glue.

Salzmann's Nodular Degeneration

SND is another condition where patients present with dry eye, grittiness, foreign body sensation, transient blurred vision and other symptoms that mimic dry eye. Sometimes the early stages of the condition may show a superficial diffuse white haze prior to the actual nodules forming, which makes the diagnosis difficult.

SND is a rare, non-inflammatory, slow, progressive degenerative condition. Women are more likely to experience SND than men; approximately 75% to 90% of all cases are in Caucasian women.[21] The average age of presentation occurs during the patient's late 50s. The most common symptom associated with SND is a foreign body sensation.[16] Approximately 63% of cases are bilateral.[22] As you can see, many of the characteristics of SND overlap with the demographics surrounding dry eye disease.

Confocal microscopy reveals that these lesions are elongated basal epithelial cells and activated keratocytes, particularly in the area of the anterior stroma near the nodules.[23] Occasional subbasal nerves and tortuous stromal nerve bundles can be observed. Ultra-high-resolution OCT images have demonstrated fibrous intraepithelial nodules with significant overlying epithelial thinning, which may contribute to dry eye symptoms.[24]

Although environment may play a role, research suggests that there may be a genetic or familial pattern of development.[25,26] Studies also have shown a high correlation to chronic ocular surface inflammatory conditions, such as keratoconjunctivitis sicca, exposure keratopathy, pterygium and epithelial basement membrane dystrophy.[27,28]

• ***Treatment.*** In mild cases where patients experience minimal irritation, various topical medications can be helpful. These include artificial tears—especially more viscous versions with longer retention time, such as Fresh-Kote (Focus Labs) or Blink Gel (Abbott Medical Optics).

If patients are more symptomatic—reporting foreign body sensation and even photophobia—topical corticosteroids, such as Lotemax (loteprednol 0.5%, Bausch + Lomb), and topical NSAIDs often relieve the inflammation and pain associated with the condition. Over the long term, patients may be treated with cyclosporine, reserving topical NSAID or corticosteroid use for more significant symptomatic episodes.

If, however, the nodules cause significant visual disturbances by severely altering the tear film or foster irregular astigmatism, a surgical treatment is recommended. Salzmann's lesions can significantly affect the corneal curvature, which is extremely evident on topography. One of the most successful treatments includes a superficial keratectomy or PTK with the application of mitomycin C. The mitomycin C prevents formation of corneal haze and/or scarring.[29] The use of mitomycin C has largely prevented any recurrence of SND, by SK or PTK.[30]

Asthenopia Conditions

Other dry eye masqueraders include the entire spectrum of asthenopia conditions, which involves computer vision syndrome, convergence insufficiency, fixation disparity or proprioceptive disparity. Patients with asthenopia typically complain of aching or pain in the eyes, dryness, redness, burning and tearing, visual fatigue with near work, a pulling feeling with near work, and headaches. Though the latter two are less likely to be associated with dry eye, the first five symptoms are typical of dry eye patients.

According to the Mayo Clinic, computer vision syndrome is defined by symptoms of sore eyes, tired eyes, burning or itching eyes, dryness and sensitivity to light.[31] Once again, almost all of these symptoms overlap with dry eye disease.

Convergence insufficiency—yet another condition in this category—presents with the common complaints of headaches, aching or pain in the eyes, dryness, burning, tearing, visual fatigue, as well as a pulling sensation to the eyes and diplopia. Other than the latter two, the symptoms are once again similar to dry eye. Finally, patients who suffer from dysphoria, fixation disparity and, in particular, proprioceptive disparity will have very similar symptoms to dry eye disease.

The key differentiation here is that dry eye testing will be normal. For example, osmolarity measurements will be under 308, corneal staining is going to be minimal to absent, tear film break-up time will be normal, and meibomian gland expression will show fairly normal meibum secretions. In this case, measuring for phorias and fixation disparity can help determine the level of proprioceptive disparity at near, distance and any vertical imbalance. Consider using a new system such as the Opt-Align (Stereo Optical), which can help take fast and accurate measurements.

• ***Treatment.*** Here, treatment would be focused on eye alignment issues, such as vision therapy, or prism correction within spectacles. With proper diagnosis and treatment, the response to eye irritation can be quite dramatic and many patients who had thought they had dry eye disease find themselves free of symptoms.

Dry eye is a common disease that is often encountered in most practices. It is the clinician's responsibility to document a thorough case history of patient symptoms and—in conjunction with a variety of clinical signs and diagnostic tests—accurately diagnose the condition and determine its severity. Keep in mind that there are many dry eye distractors, and these conditions require separate treatment and management. RCCL

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CE TEST

1. What is NOT a common indication for recurrent corneal erosion (RCE)?
a. Acute pain upon waking.
b. Blepharospasm.
c. Itching.
d. Photophobia.

2. What is the most common cause of filamentary keratitis?
a. Keratoconjunctivitis sicca.
b. Phototherapeutic keratectomy (PTK).
c. Blepharitis.
d. Trauma.

3. What is the recommended treatment for filamentary keratitis?
a. Artificial tear supplements.
b. Address the underlying ADDE syndrome.
c. Control the inflammation through anti-inflammatory agents and/or steroidal pulse dosing and an immunomodulator.
d. All of the above.

4. What are some intrinsic causes of meibomian gland dysfunction (MGD)?
a. Low blink rate.
b. Contact lens wear.
c. Vitamin A deficiency.
d. Allergic conjunctivitis.

5. What is mucus fishing syndrome?
a. Excessive evaporation of tears from the ocular surface.
b. Corneal condition where degenerated epithelial cells and mucous attach to the cornea.
c. Chronic condition where ocular irritation can cause cells to produce excess mucus.
d. Development of mucus secondary to intraocular surgery.

6. What is a symptom of floppy lid syndrome?
a. Chronic conjunctival injection.
b. Blurred vision.
c. Foreign body sensation.
d. None of the above.

7. Salzmann's nodular degeneration (SND) is…
a. More likely to present in men than women.
b. More likely to present in a patient's late 20s.
c. Most commonly presented initially with a foreign body sensation.
d. Is never noted bilaterally.

8. How are mild cases of SND treated?
a. Artificial tears.
b. Topical corticosteroids.
c. Topical NSAIDs.
d. All of the above.

9. What is NOT a symptom of computer vision syndrome?
a. Burning or itching eyes.
b. Foreign body sensation.
c. Sensitivity to light.
d. Dryness.

10. Which symptom of convergence insufficiency is also a symptom of dry eye?
a. Headaches.
b. Diplopia.
c. Pulling sensation to the eye.
d. None of the above.

Examination Answer Sheet

Valid for credit through September 1, 2015

This exam can be taken online at www.reviewofcontactlenses.com.
Upon passing the exam, you can view your results immediately.
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Directions: Select one answer for each question in the exam and completely darken the appropriate circle. A minimum score of 70% is required to earn credit.

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Lesson 108536 RO-RCCL-1012

A Blueprint of Tomorrow's Smart Lens

Wearable computers and revolutionary treatments may be as few as five years away.

By Jerome A. Legerton, O.D., M.S., M.B.A.

Dr. Legerton is an author, lecturer, inventor and consultant to the ophthalmic industry. He is a cofounder of SynergEyes and Innovega, and has 33 issued U.S. patents for contact lens technology including Synerg-Eyes, Paragon CRT, myopia progression control, presbyopic laser refractive surgery, and novel multifocal contact lenses. A recent patent is assigned to Innovega for the iOptik contact lens enabled wearable computer.

Can you imagine your smartphone or laptop screen displayed directly through your contact lens? The possibilities are endless. Imagine being lost in the city and needing directions. Easy! A map overlay appears in your visual field. Or sitting bored in a reception room—flip through a book or watch your favorite movie. Better yet, maybe you don't have to come into the doctor's office at all because your practitioner can remotely monitor your condition using biometric sensors in the lens. The truth is that this reality—once strictly the domain of science fiction—is not too far away.

As with any cutting-edge technology, smart contact lens research has advanced markedly even just since last year's preview of projects in the pipeline ("*The Future is Now: Unveiling Smart Contact Lenses*," *May 2011*).[1] New technology reports, published patent applications and clinical trial data presentations indicate an emerging megatrend in consumer electronics that is forecasted to impact millions.

Industry leaders propose a tantalizing future: Contact lenses will ultimately be the preferred display console for wearable computers, offering a seamless merging of the physical and the digital worlds (so-called augmented reality, or AR). At the same time, these technologies also will be applied to medical monitoring, telemedicine, low vision, and defense and security.

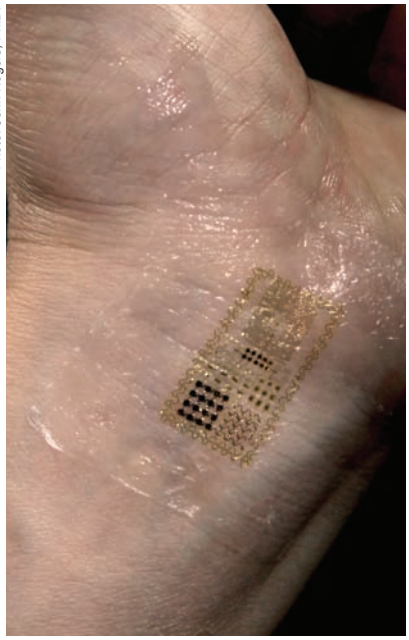
Industry Predictions

The defining milestone in the evolution of smart lenses was the

success in incorporating passive and active components directly within contact lenses, rather than as external components; it was never going to be practical to expect users to wear an external battery pack or recording device. This breakthrough was made possible in part by the phenomena of Bell's Law and nanotechnology. Bell's Law is a function of the 100 times reduction in size of electronics every 10 years.[2] Mainframe computers, once enormous, are now reduced to the size of the head of a pin.

A number of technologists are developing sensors, processors, power sources, wireless antenna and other microelectromechanical systems (MEMS) that are small enough to be placed in contact lenses. The added challenges of making the components biocompatible, able to be sterilized, low cost and robust in a hydrated substrate are also being addressed.

Photo: John Rogers, Ph.D.



1. Wearable electronic sensor for heart activity will communicate with a contact lens-enabled wearable display.

A telltale indicator of the future can be found in the public comments of a number of thought leaders and decision makers in information technology, video gaming and telecommunications. Michael Abrash, a Microsoft veteran and major contributor at Valve, a very forward-thinking video game company, said, "The logical endpoint is computing everywhere, all the time—that is, wearable computing." In outlining a possible technological timeline, Mr. Abrash said that in 20 years, wearable computing will be the industry standard—but he expects to see the technology make a mainstream appearance within 10 years, and as soon as in three to five years. "The key areas (input, processing/power/size and output) need to evolve to enable wearable computing are shaping up nicely, although there's a lot still to be figured out," he said.[3]

Recent patent approvals seem to confirm Mr. Abrash's prediction.[4] Canon, for example, has 58 U.S. patents covering head-mounted displays (HD) and augmented reality (AR) technologies, while Microsoft and IBM each have 53 HD and 41 AR patents to add to their growing U.S. portfolios.

Google has earned 36 U.S. patents, with another four pending applications related to this technology. Ten of the issued patents claim designs for eyewear, while the remaining 26 relate to the technology for eye tracking, eye-based cursor movement and content selection, as well as content modulation that incorporates hand, finger and head movements. In an interview about the project, Steve Lee of Google said, "Smartphone-like contacts are the next natural step in the process."[5]

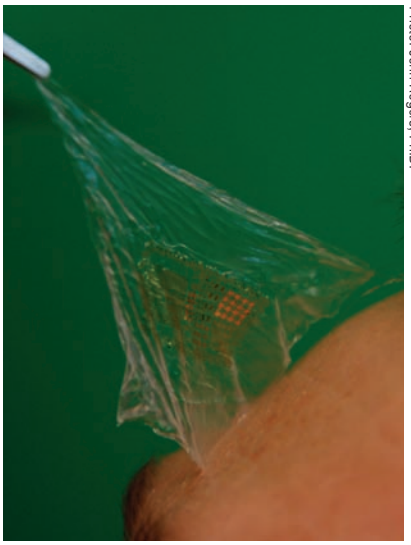


Photo: John Rogers, Ph.D.

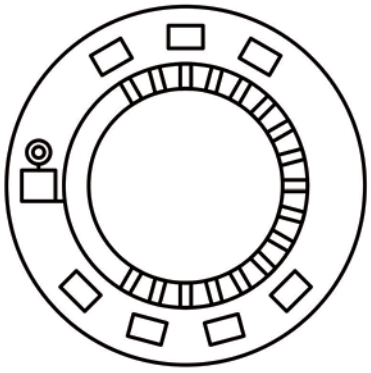
2. Removing an electronic sensor for measuring brain activity.

Valve's co-founder, Gabe Newell agreed.[6]

Google's trailblazing, spectacle lens enabled Project Glass will even make wearable computer "eyeware" a fashion statement by walking the runway at the Diane Von Furstenberg show in 2013.[7] Google Glass is a lighter form, more similar to conventional eyewear when compared to early images of the Microsoft Kinect 2 or the Oculus Rift products.[8,9]

Clinical Applications

Is AR technology simply a means of staying connected in an increasingly digital world, or does it offer potential clinical benefits as well? Several technology teams are working on methods of measuring IOP and blood sugar through contact lenses, including the Triggerfish lens from the MEMS technology leader Sensimed.[10-12] Clinical trial data were recently reported for IOP-monitoring contact lenses; the study concluded that repeated use of the contact lens sensor demonstrated good safety and tolerability. The recorded IOP patterns

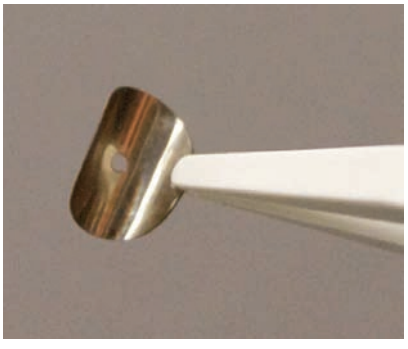


3. Refractive therapy contact lens with programmable light sources.

showed fair to good reproducibility, which suggests that data from continuous 24-hour IOP monitoring may be useful in the management of patients with glaucoma.[13]

Microsoft and the University of Washington conducted an animal study on the use of a contact lens to sense blood sugar levels; no corneal damage was found on the tested rabbits.[14]

Other teams are developing wearable sensors for EEG, EKG, blood pressure, pulse and other body functioning monitors (*figures 1 and 2*).[15] Currently under development is an array of wearable sensors which can communicate to monitors that can also be worn. The practicality of this technology is threefold: Patients can closely monitor their own bodies and have access to direct quantitative data; sensors can directly communicate with practitioners or healthcare systems; and, ultimately, the sensors may communicate to wearable pumps or electrostimulus systems that deliver pharmaceuticals or stimuli, with monitoring by the patient or the practitioner through the cloud. This research is being led by John Rogers, Ph.D., and colleagues at Northwestern University and the University of Illinois at Urbana-Champaign.[15]



4. Gas-permeable nanopolarizer for iOptik contact lens.

Measurement is the first step to modulation. The internal eye and the tear film provide other valuable systemic information. It is anticipated that sensors in a contact lens can measure blood alcohol level and tear film components, including inflammatory mediators. These sensors could provide warnings to the wearer and could drive release of anti-inflammatory or other ocular surface therapeutic agents to modulate ocular surface health and comfort.

Therapeutic Devices

Treatment of seasonal affective disorder (SAD) using external light sources that attempt to reset the patient's circadian rhythms have been of limited benefit because it currently requires patients to sit in front of a light box each day for lengthy periods of time. The field could be revolutionized by research currently underway to use contact lenses with light-emitting diodes in a prescribed wavelength to stimulate the pineal gland through the non-image retinal pathway. The resultant modulation of seratonin would help control one's mood, without the tedium of using a light box. This potentially groundbreaking science is being investigated by researchers in Jacksonville, Fla.; the team has recently published several patent applications on these lenses.[16]

Preventive Science, Inc., has similar technology for the regulation of refractive error with an emphasis on the prevention of myopia.[17] Known as "eyewear-borne electromagnetic radiation," this technology incorporates light sources in contact lenses to provide a prescribed wavelength, direction, retinal area, illumination level and duration for the regulation of refractive error (*figure 3*). Recent publications point to the role of near visible ultraviolet light, as well as the role of outdoor light exposure in animal models and humans, to support the future use of contact lenses with illumination sources for refractive therapy.[18-21]

Drug Delivery

The most visible breakthrough in drug delivery smart lenses is the reported success in sustained drug delivery with imprinted drug-eluting contact lenses, from graduate student Arianna Tieppo and colleagues at Auburn University.[22] In addition, tests on the slow release of antibiotics with fibrin-coated lenses showed mix results. The lenses loaded with gentamicin performed better than those soaked in gentamicin, however the results varied with other antibiotics, according to Ph.D. student Alex Hyatt and colleagues at University of Cambridge.[23]

Other advances in this field include the use of a sandwiched layer of PLGA (poly-lactic-co-glycolic acid), a biodegradable polymer to regulate the amount of pharmaceutical that passes through the lens over time, by researchers at Boston Children's Hospital.[25]

Restoring and Enhancing Vision

On *The Six Million Dollar Man*, Steve Austin's "bionic" eye provided image magnification and enhancement that proved vital to his missions. On *Star Trek: The Next Generation*, Geordi LaForge's visor restored vision lost to blindness. One day, low vision patients and soldiers might achieve something akin to these fictional breakthroughs in a wearable, removable contact lens, without need for prosthetics or implants.

The Innovega iOptik contact lens technology features the first gas-permeable polarizer component that can be incorporated in rigid and hydrogel substrates. Polarization is one means of separating the display optical path from the optical path for the normal real world visual content (*figure 4*). The first clinical trials, conducted at the Naval Medical Center San Diego, demonstrated high-contrast photopic and low-contrast mesopic visual acuity equivalent to best spectacle-corrected baseline measures while demonstrating display visual acuity at the highest resolution that the display could present (0.2 logMAR, 20/32).[26]

The first generation iOptik contact lens is expected to use the NormalEyes 15.5 (Paragon Vision Sciences) mini-scleral lens (*figure 5*). This smart lens system is forecast to provide help for low vision patients by the delivery of electronic image amplification and image presentation.

5. Passive optics iOptik mini-scleral lens on NormalEyes 15.5 platform to enable a "wearable computer."

This hands-free, full field of view software-modulated system will allow more magnified content to be seen than previously visible with spectacle-mounted conventional telescopes, microscopic systems or closed-circuit electronic display systems.

The eyewear will use lightweight lenses that incorporate a transflective diffuser to reflect red, green and blue laser-generated images from a small pico projector mounted in the temple of the frame. The first-generation system is engineered to provide 720p resolution over a 90° field (*figure 6*).

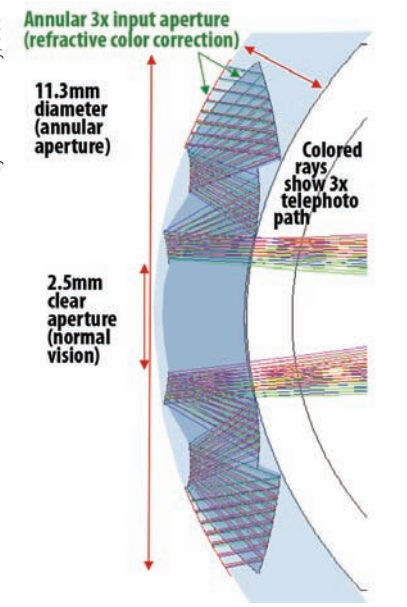
6. iOptik off axis projection with transflective diffuser 90° field eyewear model.

For soldiers, a lens that will provide full-field imaging of an eyewear display and a hands-free zoom telescopic function is currently under development under the Defense Advanced Research Projects Agency program, SCENICC (soldier centric imaging via computational cameras). The telescopic function of the lens is provided by folded reflective optics, which collapses the telescopic path to a thickness that can be incorporated into a contact lens (*figure 7*).

This is the first wearable scleral lens with folded optics, which delivers a 3X telescopic path and a normal 1X path. The lenses will incorporate polarizers to allow switching from the normal 1X path to the telescopic path as needed. The hands-free zoom lens is forecast to add to the prescription armament for low vision patients in addition to the defense application. A primary advantage of the system is the high levels of light transmission of the telescopic path due to the image gathering in an annulus, which is located outside the pupil. Novel systems for oxygen transmission are included in the lens (*figure 8*).

This entire project is spearheaded by University of California San Diego, in conjunction with Innovega and a number of technology companies. The lens was developed by Paragon Vision Sciences. The optics and patented technology were designed by Joseph Ford, Ph.D., and colleagues at the

Photo: Photonic Systems Laboratory, UCSD.

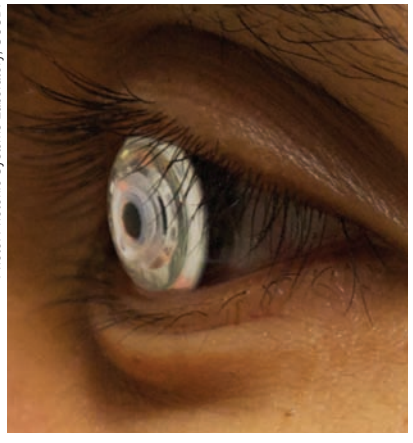


7. Hands-free zoom telescopic contact lens ray tracing.

Photonics Systems Integration Laboratory at UCSD.[27]

Smart contact lens technology is coming, and it is well thought out. Even so, these products will present new regulatory questions and require new medical device roadmaps. Some will be easier and faster to commercialize than others. It is anticipated that passive systems will reach the market with the shortest regulatory time, although active systems like the MEMS-containing Triggerfish have pioneered the way for others to follow.

Photo: Photonic Systems Laboratory, UCSD.



8. Hands-free zoom (1x to 3x) telescopic contact lens without cosmetic layer.

We can anticipate that there will be ethical issues and concerns about visual performance. Just as eye care professionals and technologists have directed attention to the safety, efficacy and human impact of 3D television and 3D game-playing, how smart lenses will affect humans needs to be better understood. Vision is a dominant sensory process and integrates dynamically with the rest of the human central and autonomic nervous system. One of the first ethical questions to address will be the safety concerns when driving while wearing these media rich lenses.

At the same time, we may likely face privacy issues because wearable computers, linked to the cloud, will be equipped with face recognition capacity. We may ultimately find that the smart lenses may be too smart. RCCL

Dr. Legerton has direct financial interest in Innovega and Preventive Science, and is a consultant to Paragon Vision Sciences.

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10 Tips for Smarter Scleral Lens Fitting

Here is an easy, step-by-step guide to successfully fit your patients in scleral lenses.

By Melissa Barnett, O.D.

Have a patient with keratoconus and can't find seem to find the right lens fit? Or perhaps a post-LASIK patient who needs improved vision and prefers contacts? Scleral lenses may be the answer. Because these large-diameter gas-permeable lenses do not impinge the cornea, they are a comfortable option for many of your patients with vision compromised by corneal irregularity and ectasia.

1. Determine an appropriate candidate.

Consider fitting scleral lenses for:

- Patients with primary corneal ectasia (e.g., keratoconus, keratoglobus and pellucid marginal degeneration).
- Patients with secondary corneal ectasia (e.g., post-LASIK, post-PRK and post-RK).
- Patients with persistent epithelial defects.
- Patients with a rehabilitated ocular surface, including cases of severe dry eyes, graft vs. host disease, Sjögren's syndrome, Stevens-Johnson syndrome and neurotrophic keratopathy.
- Patients with inflammatory conditions, such as limbal stem cell deficiency and ocular cicatricial pemphigoid.

Since we currently do not have data on the long-term impact of scleral lens wear on the normal cornea, such use is considered controversial and not recommended. However, refractive error, astigmatism and presbyopia can all be corrected with scleral lenses.[1-9]

2. Find your starting point.

Each type of scleral lens has a unique fitting philosophy; thus, it is important to first read the individual fitting guide. This will help you determine a starting point and provide an outline for how best to fit the lens.

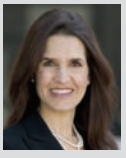
Start with a physical examination to evaluate the anterior segment. In particular, look for corneal staining and the appearance of the eyelids, including signs of meibomian gland dysfunction.

Scleral lenses are fit on sagittal depth—the measurement from the flat plane to the highest point of a concave surface. Since not all practitioners have immediate access to an anterior segment OCT, corneal topography is recommended to evaluate the cornea to determine a starting point for the fit.

Due to a poor endpoint in patients with corneal ectasia and ocular surface disease, subjective refraction may or maybe not helpful. Keep in mind that the refractive endpoint does not tend to correlate with the scleral lens power.[9,10]

3. Avoid bubbles during lens insertion.

When inserting the scleral lens, ask your patient to bend over so his or her face is parallel to the horizontal plane. It is important to completely fill



Dr. Barnett is a principal optometrist at the UC Davis Medical Center in Sacramento, where she performs primary care and eye examinations and fits contact lenses, including specialty lenses. She also lectures on optics and contact lenses to ophthalmology residents.

the scleral lens with non-preserved sodium chloride solution. Try holding the eyelids open for easier lens insertion.

If bubbles appear, consider using a thicker non-preserved agent to fill the bowl of the lens (e.g., carboxymethylcellulose sodium solution). Remember that the bowl of the scleral lens should be filled upon insertion, and should not drain out. If a bubble does occur, remove the scleral lens and reinsert.

4. Allow the lens to settle.

When a scleral lens is first placed on the eye, it may appear to fit well. However, the lens settles into the conjunctiva with time and the fit may appear quite differently a few hours later. When scheduling your patient's initial fitting and follow-up dispensing appointment, allot extra chair time accordingly. Also, consider asking your patient to return four hours after your initial appointment to better gauge the lens fit.

5. Evaluate scleral lenses with fluorescein.

A few hours after your dispensing appointment, reevaluate the lens fit with fluorescein and white light to guarantee that fluid exchange is occurring with lens wear. If fluorescein is still present at that time, then evaluate the lens fit. If fluorescein is not present, apply a fluorescein strip to the conjunctiva to evaluate for fluorescein uptake under the lens.

6. Assess corneal clearance.

Note that there is no set amount of central corneal clearance required under the scleral lens. Smaller corneo-scleral lenses may only need 20µm to 30µm, whereas larger diameter scleral lenses may go up to 500µm. Instead, the amount of clearance varies with the condition.

Consider larger diameter lenses when a greater sagittal height is necessary, in cases of keratoglobus or when keratoconus presents with large differences in corneal sagittal height. On the other hand, post-corneal grafts or corneal scars may need a smaller sagittal height.

Keep in mind that corneal thickness may be useful as a comparison and reference. Normal corneas have an average thickness of 535µm (centrally) and 650µm (peripherally). With corneal ectasia patients, corneal center thickness may be significantly thinner.[11,12]

7. Evaluate the periphery of the lens.

When evaluating the fit of the scleral lens, address common complications. For example, conjunctival blanching, with a white appearance, is caused by pressure on the conjunctiva. Circumferential conjunctival blanching is a result of a landing that is too flat or too steep. In these situations, changing the fit of the peripheral curves may improve the fit of the lens.

If the blanching is under the entire area of the scleral lens, it may be necessary to increase the landing zone by increasing the lens diameter. If blanching is under the scleral lens edge, this may cause conjunctival staining and hypertrophy over time.

Sectoral conjunctival blanching may occur due to an irregular scleral shape. If this presents, a non-rotationally symmetrical lens may help create a more ideal fit. If a pinguecula is present, create a notch in the lens to leave additional room.

Impingement—when the lens edge pinches the conjunctiva—occurs when negative pressure builds up behind the scleral lens with the blink. As the scleral lens flattens with the blink, fluid escapes. Conjunctival staining and hypertrophy may be present after lens removal. In order to eliminate impingement, consider decreasing the sagittal depth, flattening the peripheral curves if the impingement is at the outer edge of lens, steepening the peripheral curves if impingement is at inner edge of the peripheral curve or increasing the center or junction thickness.

8. Evaluate for lens flexure.

If your patient complains of blurred vision or astigmatism on spherocylindrical over-refraction, evaluate for lens flexure by performing keratometry or topography over the lens. It may be necessary to increase the center thickness of the lens to reduce warpage.

9. Take care when removing the lens.

A large or small DMV plunger (DMV Corporation) is useful when removing scleral lenses. The plunger is squeezed to induce suction and then applied to the periphery of lens. Remember to avoid the central part of the lens. Once suction is induced, twist and pull the plunger and lens away from the eye to remove the lens.

Scleral lenses may also be removed by the manual two-finger method. After the patient looks down, move the lower eyelid outward while applying mild pressure to the eyeball, then gently push the lower eyelid with the index finger underneath the lower edge of the lens in order to remove the lens.

10. Stay informed.

The best way to keep abreast of new developments is to stay informed. The Scleral Lens Education Society (SLS) is a non-profit organization and resource website (www.sclerallens.org) dedicated to teaching practitioners how to fit all different types of scleral lens designs in order to manage corneal irregularity and ocular surface disease. RCCL

References available at www.reviewofcontactlenses.com.

Tech Treatments for the Thinning Cornea

For eye care practitioners, today's technology offers a more comprehensive management plan.

By Melissa Barnett, O.D.

This is an exciting time to be treating our patients who suffer from corneal ectasias. For patients with keratoconus, relatively new treatment options include scleral lenses and collagen cross-linking (CXL). For patients with failed corneal grafts, keratoprosthetics might offer a second chance at restoration of vision they wouldn't otherwise have thought possible. This article will provide an overview of the technology available today for these three options.

Scleral Lenses

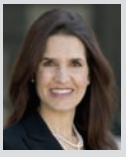
First introduced in the late 1800s, today's modern scleral lens is easily reproducible and manufactured by several different companies.[1,2]

Scleral lenses have many indications, including primary and secondary corneal ectasias, post-corneal transplants, corneal scars, and corneal dystrophies or degenerations.[3] Scleral lenses also can be prescribed for patients with severe dry eye, graft vs. host disease, Sjögren's syndrome, Stevens-Johnson syndrome, neurotrophic keratopathy or chronic inflammatory conditions such as limbal stem cell deficiency and ocular cicatricial pemphigoid.[3]

Scleral lenses benefit patients with keratoconus by normalizing corneal irregularities. The fluid between the cornea and scleral lens creates a smoother surface, thus neutralizing an irregular corneal surface.[4]

Depending on the amount of corneal ectasia, different scleral lens diameters may be used. Large diameter lenses are able to create a greater tear reservoir and provide more clearance between the lens and the cornea. This is useful if there is a significant difference in corneal sagittal height (ectasia). Large diameter scleral lenses have a wider area of bearing in the landing zone, which may improve lens comfort. Smaller diameter scleral lenses are easier to handle and may be used when there is less corneal ectasia. When fitting scleral lenses, the most important goal is to clear the cornea completely. In some cases, this can be accomplished through the smaller diameter lens. But keep in mind, scleral lenses should be incredibly comfortable so be flexible and switch between larger and smaller diameters to find the right fit.

When a larger diameter lens still does not provide complete corneal clearance, it may be helpful to make a larger change in sagittal depth. The amount of clearance needed varies with the condition. You may need a larger sagittal height in cases of keratoglobus, when rehabilitating patients with ocular surface disease or, as mentioned earlier, when a patient presents with a significant difference in ecstasia. On the other hand, post-corneal grafts or



Dr. Barnett is a principal optometrist at the UC Davis Medical Center in Sacramento, where she performs primary care and eye examinations and fits contact lenses including specialty lenses. She also lectures on optics and contact lenses to ophthalmology residents.

corneal scars may require a smaller sagittal height.

Corneal thickness may also be useful as a comparison and reference. For normal eyes, the average corneal thickness is 535µm centrally and 650µm peripherally. However, with corneal ectasias, central corneal thickness may be significantly thinner.

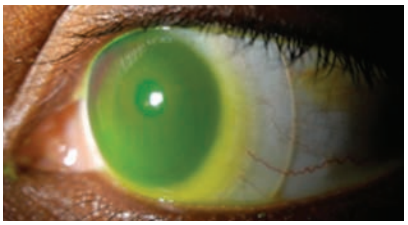
Corneal Collagen Cross-linking

Cross-linking frequently is used within the polymer industry to harden materials, and in bioengineering to stabilize tissue. In recent years, researchers have developed clinically effective protocols that use riboflavin and UV light to strengthen the cornea by increasing the crosslinks within the collagen fibers. CXL has been used internationally for more than a decade, but the FDA still considers it an off-label procedure. In the United States, a 10-center prospective, randomized clinical trial ran from December 2007 to April 2011 to determine the safety and effectiveness of corneal cross-linking performed in eyes with progressive keratoconus. Data has been collected and the results are pending.[5]

Although CXL halts the progression of corneal ectasia, causes flattening of keratometry measurements, and improves uncorrected and best-corrected vision, it does not fully correct refractive error or eliminate the need for glasses/contact lenses.

Investigations into the possibility of inducing cross-linking in the corneal stroma as a conservative treatment for keratoconus began in the mid-1990s. The biomechanical behavior of the cornea could be altered by irradiation using ultraviolet light with photosensitizers and through aldehyde reactions, as demonstrated by Eberhard Spoerl, Ph.D., and Theo Seiler, M.D., Ph.D.[6]

The porcine corneas were treated with glutaraldehyde, Karnovsky's



1. Scleral lens on a patient with keratoconus.

solution (glutaraldehayde and paraformaldehyde), or riboflavin and UV irradiation. These treatments caused an increase in corneal stiffness compared to untreated corneas.[6] Riboflavin is a non-toxic photosensitizer comprised of vitamin B2, which is water-soluble. It can penetrate easily into the corneal stroma in the absence of the corneal epithelium.

CXL was first performed in 2003 by Gregor Wollensak, M.D., and colleagues.[7] In patients with preoperative progressive keratoconus, CXL appeared to halt the progression of corneal ectasia.[7] It has been documented that CXL causes flattening of keratometry measurements—from 1.45D to 2.68D at follow-up, depending on the study. There also tends to be improvements of uncorrected and best-corrected visual acuity with the flatting of the cornea (results vary).[7,8] Untreated eyes had further steepening of keratometry readings and worsening of best-corrected visual acuity.[9]

Generally speaking, CXL is a safe and effective procedure. About 85% to 90% of UVA radiation is absorbed in the anterior 400µm of the cornea. CXL is not recommended for patients with corneas thinner than 400µm.[10]

• ***Epi-off CXL***. The typical procedure for CXL involves applying a topical anesthetic, then removing 7mm of the central corneal epithelium to allow a uniform diffusion of riboflavin into the stroma.[10] Next, riboflavin 0.1 % solution is applied prior to UVA irradiation to act as both a photosensitizer and a UV blocker.[10] Homogenous UV irradiance of 3mW/cm^2 and a wavelength of 370nm is used to irradiate the cornea for a 30-minute period. An antibiotic ointment is applied post-treatment until the cornea has reepithelialized.[6]

• ***Epi-on CXL***. Cross-linking also can be performed without epithelial debridement. Studies are currently investigating whether the epithelium should be partially or completely removed during the cross-linking procedure. An advantage to leaving the epithelium intact is that both the procedure and the postoperative healing period is more comfortable for the patient.

The risk of infection may also be reduced with an intact epithelium. However, when the epithelium is intact, there may be an increase in procedure time, as it may take longer for the corneal stroma to absorb enough riboflavin. In fact, epithelial debridement may be needed to achieve stromal saturation of riboflavin during the procedure.[6]

Different techniques currently are being explored to make the epithelium more permeable. These can range from scratching to chemical treatment with topical anesthetics or preservatives to help the large riboflavin molecule more easily pass through the epithelium.

• ***Postoperative Care***. After surgery, CXL healing generally has been shown to be unremarkable, with the exception of slight transient stromal edema until corneal re-epitheliazation.[6] There are no changes associated with corneal or lens transparency, nor is there any evidence of cataract formation. Retinal damage is not observed with CXL. Additionally, CXL does not alter the ability to wear contact lenses postoperatively.

Topical antibiotics and anti-inflammatory drops are used after CXL. If the corneal epithelium is

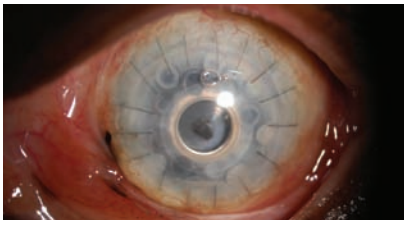
removed, a bandage contact lens may be indicated.

Stromal haze, however, has been reported after CXL treatment.[11,12] In one study, the stromal haze developed between the second and third postoperative months and was resistant to topical steroids. Six months after CXL, stromal haze was unchanged and did not impair best-corrected visual acuity postoperatively. Conversely, stromal haze did impair best-corrected and uncorrected visual acuity. Thinner corneas and reticular hypo-reflective microstriae demonstrated by confocal analysis were risk factors for stromal haze. The haze may be associated with the depth of the cross-linking procedure and the amount of keratocytes lost.[6,11] Patients with advanced keratoconus are at higher risk of haze development due to their thinner corneas and steeper corneal curvatures.[11]

Another finding after CXL is a thin stromal demarcation line over the entire cornea at a depth of approximately 300µm.[13] The demarcation line is visible beginning two weeks after treatment and does not cause any changes in the corneal endothelium, the lens or intraocular pressure. The stromal demarcation line may be due to changes in the refractive index between the untreated and treated cornea, or may be due to the reflection properties of treated and untreated corneas.[11]

CXL may be able to delay or help avoid corneal grafts in patients with keratoconus. It may also be able to create a cornea more receptive to contact lenses and improve the functional refraction with contact lenses.

After CXL, you must address the patient's refractive error. A refraction for glasses and a contact lens fitting should be performed. Keep in mind that the curvature of the cornea may change over months, so repeated refractions, corneal topographies and contact lens adjustments must be performed.



2. Boston keratoprosthesis.

Keratoprosthetics

A synthetic (or partially synthetic) keratoprosthetic device can replace an opaque human cornea to provide a clear view through the front of the eye. In the keratoprosthesis procedure, a severely damaged or diseased cornea is surgically replaced with an artificial cornea. This procedure is used for severe corneal opacities, failed corneal transplants, or when standard corneal transplants are unlikely to succeed.[14]

Keratoprosthetics are made of clear plastic with excellent tissue tolerance and optical properties. They vary in design, size and implantation techniques, but consist of three parts and, when fully assembled, have the shape of a collar button.

The two devices currently approved for use in the United States are AlphaCor (Addition Technology) and the Boston keratoprosthesis (Boston KPro).

• ***AlphaCor.*** Made of pHEMA, AlphaCor consists of two parts: a transparent, low-water content central core and a cloudy, high-water content outer porous skirt.

The AlphaCor procedure is executed in two stages, performed approximately three months apart. In the first part, a 180º degree incision is used to place the implant within the central portion of the diseased cornea. The outer conjunctiva is then placed over the implant to assist healing. Three months later, the outer half of the cornea is removed to provide a clear view into the eye.[15]

• ***Boston keratoprosthesis.*** Developed by Claes Dohlman, M.D., Ph.D., the Boston keratoprosthesis (also referred to as the KPro) consists of a central PMMA plastic button with a surrounding human donor cornea skirt. In the one-time procedure, the device is inserted into a corneal graft and then sutured into the patient's cornea. If the crystalline lens is present, it is removed. A soft contact lens is then used to bandage the surface. The donor cornea is placed on the front collar button and a titanium screw locks the KPro device into proper alignment.

If the eye is otherwise healthy, vision should return more rapidly than with the AlphaCor procedure. KPro currently is the most frequently used artificial cornea both nationally and internationally.

Potential complications with artificial cornea procedures include infection, device melting, hemorrhage during surgery, worsening glaucoma, acute retinal necrosis, chronic hypotony and poor visual potential if the retina and optic nerve are unhealthy.[16-18]

Next time you encounter a case of clinically significant corneal ectasia, take comfort in knowing that there are several promising options to help that patient. Scleral lenses have been a tremendous benefit, with the added advantage of offering a non-invasive and reversible solution. Although collagen cross-linking is not yet FDA approved, you may want to preemptively create a list of patients who may benefit from the procedure upon its eventual FDA approval. Finally, patients with failed corneal grafts are no longer bereft of options—a keratoprosthesis may allow for meaningful improvement in vision. RCCL

References available at www.reviewofcontactlenses.com.

By Gary Gerber, O.D.

A Man for All Seasons

An easy way to grow your practice is to market additional services to your existing patient base.

It's now October. With Halloween only a few weeks away, costume stores are in the middle of their busy season—but will soon be having final clearance sales. For 60 days, business is brisk, then it disappears. The same goes for ice cream shops, which usually take their winter hiatus around November, only to reopen in April. And for the skiers, resorts are just starting to take reservations but they too will close their doors come March. Chimney sweeps are busy just before the winter, roofers in the summer—both professions hoping they can live off their earnings for the rest of the year.

What do all of these situations have in common? They are cyclical seasonal businesses and, for the most part, survive on the "make hay while the sun shines" principle. However, not all businesses are dependent on this premise.

Take landscapers. During the summer, our landscapers cut lawns, trim shrubs and, more often than not, work seven days a week. In the winter, they adapt and plow driveways. But what if there isn't much snow? Can they stay busy by cutting and delivering firewood, doing interior clean outs (like basements) and pressure-washing houses?

Who would hire landscapers to clean out their basement? Perhaps it is the same person who hired them to mow their backyard—because the landscaper might have previously mentioned that he also has other trade expertise.

A Multi-Tasking Tip

The lesson here is simple. As eye care practitioners, we have a lot of patients who wear contact lenses. Therefore, we should model our business practice after the landscaper and consider what other expertise we can offer our patients. Remember that we have already established a working relationship with our patients, and they come to us for our services and presumably leave pleased with the results. It is markedly easier, faster, less expensive (and therefore, more profitable) to build on this relationship and get that patient to purchase additional products and services from your practice, than it is to establish an entirely new relationship with another prospective patient.

Other practitioners are already doing this. For example, a dentist will fill cavities one day and whiten the teeth of the same patient another day. LASIK surgeons may double their value by providing additional services such as Botox (onabotulinumtoxinA, Allergan) to their post-op patients. Using the same principle as the landscaper, they are capitalizing on a pre-established bond between "the buyer and the seller."

For the Contact Lens Fitter

We have many services that we can offer our contact lens patients. Let's start with other contact lenses. If your patients aren't currently wearing daily disposable lenses as their mainstay lenses, you can suggest them as an adjunct for special occasions, sports, travel, etc. Similarly, patients who wear clear lenses can be introduced to the rainbow of colors and designs currently available. We can tell our monovision and multifocal patients about other alternatives that may be convenient for different situations.

Finally, don't forget to mention eyeglasses. It is actually amazing how poorly eye care practitioners do in this area. We should stop allowing a -5.00D contact lens patient to "make do" with a pair of -3.00D eyeglasses.

Approach this practice-building strategy from the perspective that you are going above and beyond by suggesting additional services or products to someone who already enjoys doing business with you. This also means that more contact lens patients will have the proper eyewear. And, continue thinking of additional revenue-generating opportunities: dry eye treatment, corneal reshaping, vision therapy, low vision and any other medical services you offer.

Stay busy by presenting your entire portfolio of services to all patients whenever clinically appropriate. One of the easiest ways to grow your practice is through the happy patients you already have on board. Cut their grass *and* plow their snow! RCCL

MYTHS, METHODS AND MEANS FOR SOOTHING END-OF-DAY CONTACT LENS DISCOMFORT

Fig. 1: Headstand in an ice bucket.

Fig. 2: Switch to Avaira®.

How far will your patients go to relieve their dry, irritated eyes? Tell your patients about Avaira® lenses for comfort that doesn't end before their day does. 8 out of 10 Avaira wearers wear their lenses for 14 hours or longer per day.* Avaira 2-week contact lenses by CooperVision™.

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What do all these patients have in common?

First-time wearers

Wearers looking for better vision

Wearers with astigmatism

NOW AVAILABLE **FOR ASTIGMATISM**

They need consistently crisp, clear vision.

Bausch + Lomb PureVision®2 and PureVision2 For Astigmatism contact lenses are designed to give your patients consistently crisp, clear vision – even in low light. Both reduce inherent and induced spherical aberration across the entire power range, and are designed for crisp, clear vision. Additionally, both feature significant design enhancements for comfort and breathability. Plus, PureVision2 For Astigmatism lenses include our unique **Auto Align Design**™ for consistent on-eye stability and fewer visual fluctuations.
Add it all up, and you've got a family of lenses that give your patients more of what they are looking for.

What wearers are saying about PureVision2 lenses:

83% of first-time lens wearers say PureVision2 lenses are the ideal lens for them[1]

87% of astigmatic wearers rate their vision with PureVision2 For Astigmatism as good to excellent[2]

84% of eye care professionals say PureVision2 provides crisp, clear vision[3]

PureVision2 and PureVision2 For Astigmatism are indicated for daily wear only.

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[1] Results from a 21-investigator, multi-site study of PureVision2 contact lenses. After 14 days of daily wear, subjects completed an online survey regarding lens performance. A total of 225 new-to-contact lens subjects completed the survey. Consumers rated the extent to which they agreed or disagreed with performance attributes on a 6 point scale (1 = strongly disagree and 6 = strongly agree).

[2] Results from a 20-investigator, multi-site cross-over study of PureVision2 For Astigmatism and PureVision Toric lenses. A total of 292 subjects completed the study. After 7 days of wear for each lens, subjects completed an online survey regarding lens performance. Consumers rated performance attributes using a 6-point scale (1 = strongly disagree and 6 = strongly agree) and using a 5-point scale (excellent, very good, good, fair, poor). At the final visit, investigators rated the extent to which they agreed or disagreed with performance attributes also using a 6-point scale.

[3] Results from a study of eye care professionals who had prescribed PureVision2 lenses. 201 eye care professionals completed an online survey regarding lens performance and rated the extent to which they agreed or disagreed with performance attributes on a 6-point scale (1 = strongly disagree and 6 = strongly agree).