The Compromised Eye: A visual guide to some of the worst complications of the anterior segment.

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departments

4 News Review
Another Possible Rx Therapy For Dry Eye?: Contact Lenses May Improve Drug Delivery

6 My Perspective
An Uncomfortable Truth
By Joseph P. Shovlin, OD

7 Lens Care Insights
Are Solutions Actually the Problem?
By Christine W. Sindt, OD

8 Pharma Science & Practice
We Will ROCK You
By Tammy P. Than, OD, MS and Elyse L. Chaglasian, OD

10 Derail Dropouts
Not So Fast...
By Jason R. Miller, OD, MBA and Mile Brujic, OD

30 Corneal Consult
What Causes a Non-healing Cornea?
By James Thimons, OD

32 The GP Expert
Setting the Record Straight
By Stephanie L. Woo, OD

34 Out of the Box
What Do You Do?
By Gary Gerber, OD

features

22 The Compromised Eye: Presentations and Pathology
A visual guide to some of the worst complications of the anterior segment.
By Christine W. Sindt, OD

12 CE — Lessons Learned: Contact Lenses, Adverse Events and Bacterial Keratitis
A look at the complex relationships between edema, lens wear patterns and ocular defenses.
By William D. Townsend, OD

18 A Breath of Fresh Air
It’s important to understand the oxygen transmissibility of silicone hydrogels, as we still need to worry about the possibility of corneal hypoxia.
By Aaron B. Zimmerman, OD, MS

26 10 Ways to Avoid Contact Lens Complications
Proper education is paramount, but key clinical decisions also help to keep contact lens wearers comfortable, compliant and complication-free.
By Douglas Benoit, OD
The results of a 12-week study suggest that a new topical drug may reduce some discomfort associated with dry eye disease.

The recently completed OPUS-2, a multicenter, randomized, double-masked, placebo-controlled, parallel-arm Phase III study, examined the efficacy and safety of lifitegrast 5.0% solution in 718 adults with dry eye. Lifitegrast is a preservative-free topical solution designed to reduce inflammation caused by the interaction of lymphocyte function-associated antigen 1 and intercellular adhesion molecule-1.

During the OPUS-2 trial, the study agent was administered twice daily for 12 weeks in dry eye patients with a history of using artificial tears within 30 days of screening. Compared to placebo, lifitegrast showed a statistically significant improvement in patient-reported symptoms of ocular dryness (p<0.0001) over the duration of the clinical trial. However, the solution did not show statistically significant improvement in inferior corneal staining via fluorescein staining vs. the placebo subjects (p=0.6186).

The most commonly reported adverse events were dysgeusia, irritation at the site of instillation and a reduction in visual acuity. However, no serious AEs were reported.

OPUS-2 is the second in a three-part series of studies that comprise lifitegrast’s Phase III development program. In OPUS-1, the first part of the development program, lifitegrast was superior to placebo in improved inferior corneal fluorescein staining (p=0.0007), but the visual-related function of the Ocular Surface Disease Index did not achieve statistical significance.

“There’s often a real disconnect between improved pre-specified symptoms (i.e., comfort) and clinical signs, such as inferior corneal staining, with various time-points being critical,” says Joseph Shovlin, OD. “Unfortunately, the FDA seems to be holding firm to its rigid standards on any new approvals; specifically, signs of improvement clinically, such as staining, must be obtained as a pre-specified endpoint.”

Developer Shire Pharmaceuticals began the third part of the Phase III development, SONATA, in December 2012. This prospective, randomized, double-masked, placebo-controlled trial of 300 dry eye patients will evaluate safety and efficacy over one year. It should be completed by mid-2014.

“The efficacy outcomes are yet to be fully determined for lifitegrast, and the Agency assures both for safety and efficacy in the approval process,” adds Dr. Shovlin. “I’m afraid a significant hurdle remains.”
Could drug-eluting contact lenses replace or augment traditional eye drops for chronic conditions in which non-compliance reduces efficacy? The technology has the capability to greatly improve ocular drug delivery, as traditional eye drops are a highly inefficient method of administering medication. Typically, only 1% to 5% of the drug actually reaches the eye when using eye drops.1

Researchers from the Massachusetts Eye and Ear/Harvard Medical School Department of Ophthalmology, Boston Children’s Hospital and Massachusetts Institute of Technology have made progress toward this goal by developing a drug-eluting contact lens used for glaucoma management. Designed using FDA-approved materials, the lenses contain the popular IOP-lowering drug latanoprost. The lenses, which are created by encapsulating a latanoprost-polymer film directly into a hydrogel contact lens, are capable of releasing the encapsulated drug into the eye over an extended period of time.

The lenses achieved latanoprost concentrations in the aqueous similar to those of daily topical administration over the course of one month in vivo—the first evidence that lenses can provide controlled release of medication to the eye for this long. In animal studies, the lenses appeared safe.

This noninvasive method of ocular drug delivery may in the future help to greatly improve both the bioavailability of drugs and patient adherence.

An Uncomfortable Truth

Throughout the years, poor lens comfort has been the number-one cause of contact lens dropout. It still is.

In the early days of contact lenses, practitioners sought the “Holy Grail” of a comfortable fit for all patients, while accepting that it was simply not possible with then-current technology. In the late 1880s, the glass scleral lens was the only option, and it was uncomfortable. Barely tolerable, it could only be worn for short periods of time.

Fortunately, comfort has improved with material and design advances over time. Ironically, we’re even fitting scleral lenses more frequently, and patients are actually comfortable for many hours of wear with these lenses.

Unfortunately, lens discomfort remains the main reason patients discontinue lens wear today; up to half of all lens wearers experience discomfort with significant frequency.1 It’s surprising that, after many decades, comfort remains the main impediment to sustained contact lens wear. Recent advances (i.e., disposable lens options, water gradient technology) have helped, but patients continue to abandon contact lenses with dismaying frequency. The commonly quoted rate of 10% is likely a gross underestimation of the actual number lost every year.

A recent publication by the Tear Film & Ocular Surface Society (TFOS) in IOVS (http://www.iovs.org/content/54/11.toc) takes a comprehensive look at this problem. I would like to provide our readers with a few of the many highlights from the 18-month TFOS International Workshop. The workshop provides current information on a wide range of topics, from an epidemiology review to management of contact lens disinfection.

- A number of factors play a pivotal role in lens-related discomfort. Contact lens material and design factors were examined as modifiable items that may help solve this common dilemma. As clinicians, we try to reduce discomfort by limiting wear time, adding wetting agents, changing lens design and care system, inserting punctal plugs, incorporating dietary supplements, altering blink behavior and attempting to improve the environment.

In the TFOS review, only two level-one factors were identified: (1) dietary supplementation (omega 6-primrose oil) and (2) altering lens design.1,2 A fascinating area of interest is the neuro-biologic aspect of discomfort. Specifically, the lens interacts with some of the most richly innervated regions of the human body.1 Several areas are targeted for further study: nerve morphology and structural changes, biochemistry of the nervous system, and integration of research from the central and peripheral nervous system.1

- The conjunctiva and related anatomy appear to be more closely linked to discomfort than any other ocular structure changes in lens wear. Of note, contact lens wear causes alterations in the meibomian glands, bulbar conjunctiva (parallel folds) and palpebral conjunctiva in the “lid wiper” zone.1,2

- The TFOS review investigated the biochemical and functional changes of the tear film in lens wear. Tear film stability (evaporation) is recognized as a very important factor in lens-related discomfort.1

- The treatment and management subcommittee identified several topics of interest, but quickly pointed out that discomfort is “relatively non-specific,” as it can result from a multitude of sources other than lenses.3 It provided a step-wise approach to managing contact lens discomfort that includes: (1) treating non-lens associated problems and coexisting disease, and (2) a focus on lens design, material and solutions.

Possible additional measures include reducing deposits, fitting steeper base curves, and using larger diameter, thinner lenses.2 Tear supplements, oral supplements, punctal occlusion and oral/topical drugs may have a role as well.

THE NEW STANDARD

This productive workgroup has done an exhaustive review of the literature and posed provocative questions; it deserves our congratulations. Contact lens discomfort remains a significant clinical challenge, and it’s a sobering fact that most wearers experience some form of discomfort over time. Nonetheless, progress is being made to improve contact lens comfort.

The TFOS work sets the standard for using today’s science to solve the challenging problems compromising comfortable lens wear. We look forward to the day when the market grows without the exorbitant number of dropouts that have stifled the industry for decades.1,2

Contact lens solutions can cause a plethora of ocular surface reactions that can range anywhere from the blatantly obvious to the surprisingly subtle. Regardless of the presentation, however, solution-related problems can negatively affect contact lens wear and potentially lead to contact lens dropout.

**THE BIG FOUR**

Although many potential complications exist, these four are the most commonly seen in practice.

- **Toxic keratopathy** is observed when a toxic substance, such as contact lens cleaner, peroxide or preservative, is placed in direct contact with the eye. When caused by lens cleaners or 3% hydrogen peroxide, the adverse effect is dramatic and can be observed immediately.

  Contact lens cleaners contain surfactants, such as alkyl ether sulfate or isopropyl alcohol, which are effective in removing contaminants from the lens surface, but, depending on the concentration, may irritate the ocular surface. Both isopropyl alcohol and hydrogen peroxide are broad-spectrum microbiocidal agents, and effectively kill 80% of present bacterial, viral and fungal contaminants within just one minute of contact.

  Each of these agents work by rapidly damaging cell membranes and causing cell lysis. Therefore, if either of these agents directly contact the corneal surface, the result is often intense pain and sloughing of the epithelium.

- **Solution-induced corneal staining** (SICS), a far less dramatic presentation of toxic keratopathy, occurs through the uptake and release patterns of the lens/solution combination. The phospholipid membrane is disrupted as the biocide is released back to the cornea, which can be observed as corneal staining. The amount of staining depends on biocide concentration, as well as the length of contact. Unfortunately, if the contact lens is not removed, and fluorescein is not instilled into the eye during progress check, the subtle signs of SICS can be frequently overlooked.

  Often, these signs are also missed due to timing. SICS onsets several hours after lens insertion and then repairs itself as the day progresses. As a result, the window of opportunity to observe this condition is very small. Regardless of whether SICS is observed, the symptoms may be progressive and present as increasing dryness and irritation.

  - **Allergic reaction.** Signs of contact lens solution allergies can include hyperemia and fine papillary changes of the tarsal plate, conjunctival hyperemia, chemosis and limbitis. These complications can manifest in varying degrees. For example, patients may present with a sense of irritation or outright itching. In more severe cases, there have been reports of systemic allergy from contact lens solutions. 1 If a patient has a suspected solution allergy, patch testing may be appropriate due to the cross over into other products, such as personal hygiene products, cleaners and pool disinfectants.

- **Dry eye.** Contact lens solutions interact not only with the ocular surface, but possibly with the lens itself. The lens/solution affinity is governed by many factors, including lens material, surfactant/biocide size and composition. Each lens/solution combination will affect protein and lipid deposition. Deposits on the lens are notorious for causing end-of-day discomfort or dryness. If a patient presents with dryness as a result of their solution, changing to a different solution, switching to daily disposable lenses or adding a separate surfactant cleaner can help reduce deposits and increase comfort.

**THE MISSING LINK?**

Solutions are a complex yet incredibly important part of the contact lens comfort and safety equation. While some problems caused by solutions are obvious, others manifest in subtle ways that are difficult to spot. This leads to dissatisfaction with lens wear and increases dropout. It is important to always keep the solution in mind—the “solution” to your problems may be simpler than you think.

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The recent emergence of selective keratoplasties has been a revolutionary development in the treatment of corneal diseases that would have previously mandated a full-thickness corneal transplant. For example, the ability to now replace only damaged endothelial corneal tissue via Descemet’s stripping endothelial keratoplasty (DSEK), or sometimes Descemet’s membrane endothelial keratoplasty (DMEK), has resulted in improved visual outcomes at a much faster rate than previously possible. Because of this quantum leap forward, the procedure has been widely adopted by corneal surgeons over the past few years, accounting for more than 30% of all grafts performed in the United States in 2009.1

In 2011, 48% of all endothelial keratoplasties were performed as a result of Fuchs’ dystrophy.2 However, despite all of the successes as a result of the procedure, there are always short- and long-term risks inherent with any surgery. Infection, graft failure, rejection and cell loss all are possible complications of endothelial keratoplasty.3 Additionally, there are shortages of available and viable tissue in many countries around the world. The safety and visual acuity improvements of DSEK/DMEK and related procedures have been profound. But another revolution in endothelial dystrophy may soon follow.

**RETHINKING ENDOTHELIAL DISEASE**

What if we had the ability to treat this devastating condition, in office, with a short course of a topical eye drop that allows healing of the damaged endothelial cells, while at the same time regenerating healthy endothelial cells? Some ongoing research suggests that this actually may one day be a possibility.

The corneal endothelium, a non-replicating monolayer of cells, is responsible for the passive diffusion of nutrients from the aqueous, as well as the hydration and clarity of the cornea through its pump and barrier functions.4 Any damage or defect caused to this structure results in a compensatory migration and enlargement of the remaining cells, as well as a loss of pump function. This then causes a loss of transparency and decreased visual acuity. Rho-associated kinase (ROCK) inhibitor is a serine/threonine kinase, which mediates the formation of RhoA-induced stress fibers and focal adhesions.5 The Rho/ROCK pathway is involved in regulating the cytoskeleton, cell migration, cell apoptosis and cell proliferation.6

A group of researchers from Japan, led by Naoki Okumara, MD, have extensively studied the use of ROCK inhibitors to promote corneal endothelial wound healing in both primate and human eyes. In 2009 they reported that ROCK inhibitor Y-27632 promoted the adhesion of corneal endothelial cells, inhibited apoptosis and increased the number of proliferating cells in primates.7 They have since studied the use of this specific inhibitor for the pharmacological treatment of human endothelial disease, early stages of Fuchs’ dystrophy and postsurgical trauma.8-9

During their studies, the researchers created endothelial damage in rabbits (who display endothelial proliferation superior to humans) and in cynomolgus monkeys (whose ability to proliferate endothelium is as limited as humans) via transcorneal freezing. In the primate study, 10mm of ROCK inhibitor Y-27632 was applied topically six times daily for 48 hours in one eye, while the other eye was used as a control. The endothelial cell density was measured four weeks following treatment via noncontact specular microscopy.

An enlargement of the remaining neighboring endothelial cells with diminished cell density (~1500 cells/
mm²) was observed in the control group, while the group treated with ROCK inhibitor Y-27632 exhibited non-compensatory cell size enlargement and an endothelial cell density of ~3000 cells/mm². They postulate that this may be caused by proliferation of the undamaged peripheral cells. Additionally, when compared to the control group, the eyes treated with ROCK inhibitor Y-27632 showed enhanced functional recovery of both their barrier and pump functions.

The investigators treated eight human corneas concurrently with the primate study—four with central corneal edema and four with diffuse corneal edema. All of the human corneas were classified as “late-stage Fuchs’ corneal dystrophy.” The subjects’ endothelial cells were exposed to transcorneal freezing for 15 seconds, followed by the application of one drop of 10mm of Y-27632 six times daily over the course of seven days. Additionally, gatifloxacin 0.3% hydrate antibiotic eye drops were used four times a day. Slit-lamp exam, noncontact specular microscopy, anterior segment OCT and intraocular pressure were performed daily for seven days. These tests were then repeated every week for one month, followed by every four weeks up to six months.

In the patients with central corneal edema, center thickness was reduced six months after treatment compared to baseline at presentation, with neither a decrease in visual acuity nor any eyedrop-related complications. No difference in corneal thickness was noted in the eyes with diffuse cornea edema.

One of these patients—a 52-year-old man with Fuchs’ dystrophy referred to the study authors for surgery—was reported on in a recent paper.10 His best-corrected visual acuity was 20/63, central corneal thickness was 703um and endothelial cell density was 737 cells/mm². After transcorneal freezing and the above described protocol of treatment, visual acuity improved to 20/20 just two weeks following treatment. Six months later, corneal thickness had reduced to 568um, with an increased average corneal cell density of 1549.3 +/- 89.7 centrally and 705 +/- 61.1 peripherally. Two years post-treatment, visual acuity remains 20/16 with complete corneal clarity.

The use of transcorneal freezing in the area of the diseased cornea, in conjunction with topically applied ROCK inhibitor therapy, could potentially be a tremendous leap forward in the non-surgical treatment of endothelial corneal disease. With only a limited case series and no statistically significant data currently reported, however, further research with larger cohorts of patients is still required to determine if this will be a clinically viable procedure.

The topic is currently generating great deal of interest amongst corneal surgeons who are searching for alternatives to costly and technically challenging surgical procedures. Patients who are reluctant to undergo surgery may also benefit from this treatment option. This technique has the potential to offer eye care providers another exciting option for our Fuchs’ dystrophy or bullous keratopathy patients.

Not So Fast...

While contact lens wear can lead to presentations of acute red eye, it’s important to first consider other potential underlying causes.

It’s bright and early on a Monday morning, and you’re just walking into your practice, ready to tackle a brand new week. Before you have the opportunity to get settled in, your receptionist informs you that an emergency appointment is coming in this morning. The patient—a contact lens wearer you’ve seen for several years—has a red eye that developed over the past few days.

The first thing that comes to mind is the suspicion of contact lens abuse, but it’s important to proceed cautiously before assuming poor compliance is the culprit.

FIRST CONSIDERATIONS

At the forefront of every successful contact lens-centric practice is the goal of maintaining proper health in our lens wearers. As such, we seek to avoid complications by prescribing lenses and recommending care systems that best match the patient’s specific lifestyles and visual needs. But of course we still encounter patients with acute red eyes.

Among contact lens wearers, such presentations are thought to derive from lens wear. Oftentimes, contact lens abuse is at the top of this list. Patients who sleep in their contact lenses have a higher rate of infiltration than those who do not.1-3 Patients who do not properly wash their hands prior to lens handling tend to have an increased risk of developing microbial keratitis.4 The incidence of microbial keratitis tends to be higher in patients who reported poor storage case hygiene, as well as in smokers.5

The importance of multipurpose disinfesting solutions was apparent in 2006 and 2007, when two contact lens solutions were globally recalled due to associations with Fusarium keratitis and Acanthameoba keratitis.6,7 In light of these recalls, we always recommend patients bring in to their appointment their contact lens solution, case and any other products they’re using, so that we can determine whether non-compliance may be contributing to any complications they’re experiencing.

Before we assume that poor compliance is the culprit of these cases of acute red eye, we must first rule out some common etiologies of the condition, such as those described below.

RULE THESE OUT

- **Mucus fishing syndrome,** an interesting condition where a patient will actually “fish” mucus out of the eye. The irritation actually causes the eye to then produce more mucus.7,8 These patients tend to become so accustomed to this that they consider it “normal” and may not report the behavior.

- **Floppy eyelid syndrome.** This condition is caused by an abnormality in the collagenous tissue in the tarsus, which causes the upper eyelid to become easily everted. It is often associated with a papillary conjunctivitis.9,10 Patients presenting with floppy eyelid syndrome tend to be overweight males.11 Floppy eyelid syndrome can also present as an acute red eye. Treatment options for mild cases include additional lubricants during the day and an eye cover in the evening. In more severe cases, horizontal shortening of the lateral upper eyelid is ultimately required to tighten the lid apposition to the globe.12

- **Adult inclusion conjunctivitis.** An ocular manifestation of a systemic condition caused by Chlamydia, this also commonly presents with a red eye. Patients respond relatively well to topical antibiotics or a combination of antibiotics and steroids. Unfortunately, the red eye will often return.

Ultimately, these patients will need a systemic antibiotic for resolution, typically either 100mg of doxycycline BID PO or a single dose of 1g of oral azithromycin.10,13 What typically distinguishes the clinical appearance in these patients is a relatively prominent follicular response on the palpebral conjunctiva, along with the bulbar hyperemia.14

- **Bacterial conjunctivitis.** This complication is often passed from one individual to another. Patients presenting with the condition as a result of contact lens overwear are typically not considered contagious, though. Patients often report a history of contact with someone who has also had a “red eye.” Bacterial conjunctivitis will typically respond well to topical antibiotic therapy.

- **Viral conjunctivitis.** This manifestation can be difficult to distinguish from a bacterial conjunctivitis. In fact, clinicians only correctly diagnose these conditions about
50% of the time. The AdenoPlus test allows for rapid identification of adenovirus, the most common pathogen associated with viral conjunctivitis. We now perform this test on every patient who presents with an acute red eye of unclear etiology.

• Allergic conjunctivitis. This condition is often associated with seasonal changes; most patients will report that their ocular allergies have returned. Be aware that there are perennial allergies that can manifest more in the winter months as a result of patients spending more time indoors with their heaters turned on. The signs and symptoms of allergic conjunctivitis respond well to topical antihistamine/mast cell stabilizer combinations.

There are more chronic forms of the disease as well. Giant papillary conjunctivitis displays the classic sign of large papillae on the superior tarsal plate, which makes it important to ever the upper eyelid of every patient presenting with acute red eye. This condition is usually associated with contact lens abuse, as lid irritation from lens deposits is thought to be a trigger. Temporary suspension of contact lens wear along with topical corticosteroids is usually an effective strategy to employ when treating these conditions.

When a contact lens wearer presents with an acute red eye, it may indeed be true that lens wear is responsible. But it is important that we look for and rule out other possible etiologies before making decisions that might deprive the patient of continued contact lens wear.

The Case of the Wrongfully Accused Contact Lens

A 60-year-old Caucasian female presented with a red and irritated left eye. She was wearing a two-week disposable silicone hydrogel toric lens and using a generic store-brand solution. She wore her lenses during the visit. At the time of presentation, she was replacing her lenses every month. Her current lenses were three weeks old. She wasn’t sure why her left eye was causing so much discomfort, and she was worried that something might be wrong with her lens. She also reported that, several weeks prior, her grandson also had a red eye that improved with drops.

Entering visual acuity with her current prescription was 20/20 OS. Anterior segment examination was remarkable for a diffuse conjunctival hyperemia. The lens was removed and the cornea was remarkable for mild punctate epitheliopathy inferiorly. The palpebral conjunctiva showed a mild papillary response as well. An AdenoPlus test was positive for the presence of adenovirus in the affected eye.

The patient’s lenses were disposed of, along with her current contact lens case. She was treated with topical ganciclovir gel 1gt QID OS based on evidence of its activity against adenovirus. At follow up five days later, there was complete clinical resolution of signs and symptoms. The drops were then used 1gt TID OS for the next three days. Contact lens wear was successfully resumed at that time.

Ultimately, diagnosing and treating these conditions quickly and appropriately will be the key to getting patients back into their lenses and preventing dropouts.

LESSONS LEARNED:

Contact Lenses, Adverse Events and Bacterial Keratitis

A look at the complex relationships between edema, lens wear patterns and ocular defenses.

By William D. Townsend, OD

LB, a 37-year-old female, presented with recent-onset pain, injection and photophobia in her left eye (figure 1). We had not seen her as a patient in more than a decade. The previous evening she was evaluated at the emergency room, diagnosed with a “corneal ulcer” and obtained a prescription for moxifloxacin 0.5%. She reported overnight wear of her balafilcon A lenses for up to, and sometimes beyond, 30 days of continuous wear.

Examination revealed a 1.5mm staining area with a dense underlying infiltrate located in the inferior nasal left cornea, approximately 2mm from the limbus. In reviewing her records I discovered that, 18 years earlier, LB had presented to our office with essentially the same history, complaints and presentation.

Despite tremendous advances in contact lens materials, solutions and manufacturing techniques, we continue to deal with many of the same contact lens complications that occurred when our patient was a teenager.

In researching historical trends in contact lens-associated infection, I perused the corneal disease section in Mays’s Diseases of the Eye 1911. As I read, I was fascinated by how much, as well as how little, we knew over a century ago about bacterial keratitis.1 But as we look back, it becomes apparent that over the past two decades many accepted and established conceptions about the association between contact lens wear and adverse events such as bacterial keratitis have been revised, or in some cases, totally replaced. Still, many issues remain unresolved.

Developing a better understanding of the epidemiology, pathophysiology and risk factors for contact lens-related complications may allow us to recognize and manage these conditions more efficiently and effectively.

EPIDEMIOLOGY OF BACTERIAL KERATITIS

Contact lens-associated bacterial keratitis (CLBK) is an infrequent complication in contact lens wearers. In 1989, Poggio et al. reported an incidence of 4.0 per 10,000 for rigid gas permeable (RGP) wearers, and 2.0 per 10,000 for extended wear.2 Based on recent reports, it appears that the incidence of contact lens-related bacterial keratitis (CLBK) has remained stable since the publication of Poggio’s study, but during that period there have been outbreaks of other, non-bacterial contact lens-related keratitis, notably Acanthamoeba and Fusarium.3

RISK FACTORS

In his 1988 text, Primary Care of the Anterior Segment, Catania listed eight contact lens-related...

ABOUT THE AUTHOR

Dr. Townsend practices in a multi-location setting. He is an adjunct professor at the University of Houston College of Optometry and preceptor for senior externs who rotate through his practice. He conducts research in pharmaceutical agents, contact lens materials and solutions, and ocular surface disease.

Dr. Townsend is a fellow of the American Academy of Optometry and president of the Ocular Surface Society of Optometry.
TABLE 1. DIFFERENTIAL DIAGNOSIS OF CLPU AND MK

<table>
<thead>
<tr>
<th>Feature</th>
<th>CLPU</th>
<th>MK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Etiology</strong></td>
<td>Inflammation</td>
<td>Infection</td>
</tr>
<tr>
<td><strong>Pain</strong></td>
<td>Mild to moderate (FB sensation)</td>
<td>Increasing, may be severe</td>
</tr>
<tr>
<td><strong>Epiphora</strong></td>
<td>Mild</td>
<td>Intense</td>
</tr>
<tr>
<td><strong>Discharge</strong></td>
<td>Mild (if any) corneal suppuration</td>
<td>Severe, progressive corneal suppuration</td>
</tr>
<tr>
<td><strong>Lid edema</strong></td>
<td>None</td>
<td>Usual</td>
</tr>
<tr>
<td><strong>Injection</strong></td>
<td>Mild to moderate (localized)</td>
<td>Moderate to severe (meaty)</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Peripheral/mid-peripheral</td>
<td>Paracentral/central</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>0.1–2mm</td>
<td>&gt;1mm</td>
</tr>
<tr>
<td><strong>Shape</strong></td>
<td>Circular</td>
<td>Irregular appearance (satellite lesions)</td>
</tr>
<tr>
<td><strong>Infiltration</strong></td>
<td>Focal and slight diffuse</td>
<td>Focal and significant diffuse</td>
</tr>
<tr>
<td><strong>Staining</strong></td>
<td>Intact or staining</td>
<td>Epithelial defect</td>
</tr>
<tr>
<td><strong>Depth</strong></td>
<td>Anterior stroma involved only</td>
<td>Anterior to mid- stromal, raised edges</td>
</tr>
<tr>
<td><strong>AC reaction</strong></td>
<td>Minimal (only if severe)</td>
<td>Flare and occasional hypopyon</td>
</tr>
</tbody>
</table>

Source: Dumbleton K. Contact Lens & Anterior Eye 2002(25);137-146.

risk factors for infectious keratitis: (1) non-compliance, (2) poor hygiene, (3) tight-fitting lenses, (4) extended wear, (5) old lenses (i.e., over six months old), (6) dirty lens surfaces, (7) recent insertion/removal and (8) contaminated solutions. A quarter of a century later, the list of risk factors has not grown substantially.

Additional risk factors consistently associated with increased prevalence of microbial keratitis include smoking, failure to properly air dry contact lens cases and not washing hands prior to handling contact lenses. Ocular surface disease, ocular trauma, systemic diseases, adnexal dysfunction, immunocompromise/ immunosuppression and ocular surgery are also risk factors for microbial keratitis.

Corneal edema has long been recognized as altering the ocular surface and increasing the potential risk of contact lens complications. Researchers have used numerous strategies in an effort to identify the concentration of oxygen required to limit hypoxia-induced corneal edema. Predictably, they demonstrated that corneal edema is inversely related to oxygen levels. HOLDEN and MERTZ determined that a minimum oxygen level of 10% is necessary to prevent unacceptable edema in contact lens wear, and discovered that there are significant variations in oxygen requirements between individual subjects. This may help to explain why, in individuals wearing the same lens material, some patients tolerate extended wear better than others.

Recognizing the importance of oxygen levels in contact lens wear, manufacturers developed high

**TABLE 1. DIFFERENTIAL DIAGNOSIS OF CLPU AND MK**

- **Etiology**: CLPU - Inflammation, MK - Infection
- **Pain**: CLPU - Mild to moderate (FB sensation), MK - Increasing, may be severe
- **Epiphora**: CLPU - Mild, MK - Intense
- **Discharge**: CLPU - Mild (if any) corneal suppuration, MK - Severe, progressive corneal suppuration
- **Lid edema**: CLPU - None, MK - Usual
- **Injection**: CLPU - Mild to moderate (localized), MK - Moderate to severe (meaty)
- **Location**: CLPU - Peripheral/mid-peripheral, MK - Paracentral/central
- **Size**: CLPU - 0.1–2mm, MK - >1mm
- **Shape**: CLPU - Circular, MK - Irregular appearance (satellite lesions)
- **Infiltration**: CLPU - Focal and slight diffuse, MK - Focal and significant diffuse
- **Staining**: CLPU - Intact or staining, MK - Epithelial defect
- **Depth**: CLPU - Anterior stroma involved only, MK - Anterior to mid- stromal, raised edges
- **AC reaction**: CLPU - Minimal (only if severe), MK - Flare and occasional hypopyon

Source: Dumbleton K. Contact Lens & Anterior Eye 2002(25);137-146.

**TABLE 1. DIFFERENTIAL DIAGNOSIS OF CLPU AND MK**

- **Etiology**: CLPU - Inflammation, MK - Infection
- **Pain**: CLPU - Mild to moderate (FB sensation), MK - Increasing, may be severe
- **Epiphora**: CLPU - Mild, MK - Intense
- **Discharge**: CLPU - Mild (if any) corneal suppuration, MK - Severe, progressive corneal suppuration
- **Lid edema**: CLPU - None, MK - Usual
- **Injection**: CLPU - Mild to moderate (localized), MK - Moderate to severe (meaty)
- **Location**: CLPU - Peripheral/mid-peripheral, MK - Paracentral/central
- **Size**: CLPU - 0.1–2mm, MK - >1mm
- **Shape**: CLPU - Circular, MK - Irregular appearance (satellite lesions)
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Contact Lenses, Adverse Events and Bacterial Keratitis

The introduction of silicone hydrogel (SiHy) lenses was hailed as a promising means of reducing the incidence of CLBK and other complications linked to overnight contact lens wear.11 In a 2003 assessment of overnight contact lens wear, Holden and coworkers evaluated the incidence of CLBK in individuals wearing high-Dk SiHy lenses.11 Their initial findings suggested that patients using these lenses for extended wear had a significantly reduced risk of CLBK compared to those wearing low Dk lenses and when ulceration did occur, none of the subjects with CLBK suffered more than two lines of visual acuity.13

Silicone hydrogel lenses provide oxygen transmissibility levels (Dk/t) four to six times greater than hydrogel materials.12 Researchers reported that enhanced oxygen levels reduced the incidence of hypoxia-related complications such as corneal striae, folds, microcysts and neovascularization, but the anticipated benefits of high-Dk lenses in reducing CLBK were somewhat disappointing.12,13 Stapleton et al. reported that the risk of microbial keratitis following 30 nights of extended wear in highly oxygen permeable lenses was equivalent to six nights of hydrogel lens wear. These are, of course, the FDA approved intervals for extended wear of these respective materials. They also noted that the frequency of vision loss secondary to keratitis was similar between the two modes of extended wear, and determined that the absolute rate of microbial keratitis in their extended wear subjects was one per 500 wearers.13

In summary, despite advancements in lens material, surface quality and significantly increased oxygen permeability, extended wear continues to be the single most significant risk factor for developing CLBK and is associated with a fivefold increase in risk of sight-threatening keratitis.13

THE DEFENSE SYSTEM

Microbes must overcome a very formidable, multicomponent defense system to infect the cornea.14 Because the eye is exposed to a broad variety of potentially invasive organisms, this defense system must be capable of reducing or clearing bacteria, viruses, fungi and protozoa.15,16 In order to infect corneal tissue, pathogens must bind to and breach the ocular surface.

Under normal conditions, the multilayer defenses of the cornea protect very well against invasion. The past decade has produced a large body of research that sheds light on how the eye protects itself from invasion by pathogens.

The initial barrier, the tear film, mechanically removes many invaders by clearance and tear flow.14 The tear film contains proteins and lipids that can inhibit bacterial replication and/or destroy microbes.14 Tear components such as lysozyme, lactoferrin, lipo-calpin and IgA possess bacteriostatic or in some cases bactericidal properties that serve to discourage penetration by pathogen.12

Glycocalyx, composed of transmembrane mucins (MUCs 1, 4 and 16), acts as a protective layer adhering to the corneal surface (apical) cells. This structure is thought to interact with secreted mucins in tears to inhibit cell-to-cell and cell-to-pathogen adherence.17 Contact lens wear or pathologic conditions such as dry eye may impair barrier function and increase risk of infection.

Corneal epithelium and anterior basal lamina (Bowman’s layer) form the next physical obstruction to invasion.14,18 Epithelium produces antimicrobial peptides (AMP) including β-defensins, molecules which can influence epithelial cells to aggressively block transit of Pseudomonas. Down-regulation of AMP inhibits clearing of P. aeruginosa from epithelium. Corneal epithelial basement membrane is also an important barrier to invasion. Some Pseudomonas species are able to traverse epithelium, while others cannot.18 The findings of Alarcon et al. demonstrate that P. aeruginosa is unable to traverse beneath the basement membrane as long as epithelial basement membrane

Fig. 1. This mid peripheral corneal lesion in patient LB was initially diagnosed as a contact lens-related peripheral ulcer (CLPU).
is intact. These findings help us understand and appreciate the protective value of an intact corneal basement membrane.

If the defense mechanisms of the eye are so formidable, what condition or event allows microbes to enter and colonize the cornea? Some clues to the answers may be gleaned from research directed at contact lens-associated adverse events.

ADVERSE EVENTS AND CLBK
An adverse event is defined as “a harmful and undesired effect resulting from a medication or other intervention.” In contact lens studies, this term is frequently used to describe conditions associated with inflammation. The presence of low Dk hydrogel lens materials on the cornea for extended wear may cause non-inflammatory events such as striae and folds, mucin balls and epithelial microcysts; these conditions often resolve when patients switch to SiHy materials. But extended wear of hydrogel and SiHy materials also cause adverse events that are primarily inflammatory in nature. It is very important to differentiate between microbial keratitis and a non-infectious adverse event because the potential loss of vision and appropriate treatment are vastly different.

A contact lens peripheral ulcer (CLPU) is regarded as an immune response, primarily associated with gram-positive bacteria. It is characterized by a focal epithelial excavation overlying necrotic tissue. It invariably involves a subepithelial infiltrate and moderate injection. These lesions are typically round in shape, and located in the mid-peripheral cornea. The most commonly isolated organism cultured in

CPLU is S. aureus. This condition is sometimes misdiagnosed as infectious keratitis. The differential diagnosis is crucial to initiation of appropriate therapy.

Wu et al. used a rabbit model of CPLU to better understand the underlying pathophysiology of the condition. The rabbits wore contact lenses for 24 hours; the variables included no bacterial exposure, exposure to live S. aureus, killed S. aureus or live S. epidermidis. A second set of variables included corneas that were scratched within, but not through, the epithelium. The third variable was contact lens wear vs. no lens wear.

Salient findings from this study include the following:

- Lesions very similar to those found in human CLPU were noted only in corneas that were scratched and exposed to live S. aureus.
- Upon removal of the contact lenses and with no antibiotic application, these lesions resolved after 24 hours.
- In all corneas exposed to S. epidermidis, regardless of an intact or scratched surface, no ulceration or reaction was noted. The authors concluded that two important factors that lead to CLPU occurs are exposure to live S. aureus and the presence of a break in corneal epithelium.

Because CLPU can mimic

EXTENDED WEAR OF LOW DK HYDROGELS CAN OFTEN CAUSE INFLAMMATORY EVENTS.
CONCLUSION

This paper has reviewed many, but certainly not all, issues related to changing concepts and understanding of CLBK and other complications of contact lens wear. Notably absent from this discussion is the role that contact lens solutions and cases play in the development of contact lens-related bacterial, amoebal and fungal keratitis. Years of research have provided us with a new understanding of how contact lens materials, surface treatments and care systems can influence microbial binding to contact lenses surfaces. These and other factors beyond the scope of this article warrant discussion in a subsequent publication.

Writing this review reinforced for me how rapidly the literature in contact lens care is changing and the importance of staying current as we strive to make contact lens wear a safe and enjoyable experience for our patients. SiHy lens use is typically associated with less severe infections than silicone lenses, but the rates and types of organisms found in contact lens-related infections are similar to what was found decades ago.

We must remain vigilant and attuned to the earliest warning signs that something is awry.

LESSONS LEARNED:

Contact Lenses, Adverse Events and Bacterial Keratitis

Fig. 3. Large hypopyon ulcer in an extended wear patient (Pseudomonas cultured).

CLBK, it is vital to differentiate between the two. Salient differences include shape, degree of pain, anterior chamber reaction and location (Table 1).

Given the similarity between CLPU and early CLBK, one might consider the former to be a precursor to the far more serious infectious condition. Sweeny and Naduvilath evaluated this potential relationship and concluded that adverse inflammatory events—i.e., contact lens acute red eye (CLARE) and CLPU—do not progress to increase the risk of CLBK.

They proposed several reasons for this disconnect. CPLUs are inflammatory in nature, and biop- sies of these lesions consistently fail to show replicating organisms in the tissue. The microorgan- isms that cause inflammatory vs. infectious conditions are very different. Strains that cause inflammatory events produce low levels of proteinases and are not able to traverse through host tissue, whereas strains that cause infection produce high levels of proteinases and thus can produce epithelial cell cytotoxicity or invade tissues.

1. According to a 1989 study by Poggio et al., which modality of contact lens wear had the LOWEST relative risk for microbial keratitis?
   b. Daily soft lens wear.
   c. Extended soft lens wear.
   d. Daily hard (PMMA) lens wear.

2. Which of the following does not increase the risk for contact lens-associated bacterial keratitis?
   a. Loose fitting lens.
   b. Overnight wear.
   c. Smoking.
   d. Poor hygiene.

3. Which of the following statements regarding corneal hypoxia and oxygen levels is correct?
   a. Corneal edema is directly related to oxygen levels.
   b. Corneal edema is inversely related to oxygen levels.
   c. Corneal edema reduces the risk of contact lens-related complications.
   d. Holden and Mertz established a minimum oxygen level of 20% to prevent unacceptable edema.

4. Silicone hydrogel lenses provide all of the following benefits except:
   a. Oxygen transmissibility levels (Dk/t) four to six times greater than hydrogel materials.
   b. Increased incidence of corneal striae.
   c. Reduced incidence of corneal folds.
   d. Reduced incidence of corneal neovascularization.

5. To protect the eye, the ocular surface defense system must be capable of:
   a. Reducing or clearing bacteria.
   b. Reducing or clearing viruses.
   c. Mechanically removing invading microbes.
   d. All the above are correct.

6. Corneal glycocalyx contributes to ocular defense and:
   a. is composed of transmembrane mucins.
   b. promotes cell-to-cell adherence.
   c. promotes cell-to-pathogen adherence.
   d. All the above are true.

7. Regarding Pseudomonas species and the cornea, which statement is correct?
   a. Corneal antimicrobial peptides (AMP) such as defensins inhibit transit of Pseudomonas through epithelium.
   b. Up-regulation of AMP inhibits clearing of P. aeruginosa from epithelium.
   c. All Pseudomonas species are able to traverse epithelium.
   d. An intact corneal epithelial basement membrane promotes traversal of Pseudomonas into the underlying tissues.

8. Which of the following is NOT true of contact lens peripheral ulcer (CLPU)?
   a. CLPU is an immune response.
   b. CLPU is strongly associated with Pseudomonas species.
   c. CLPU is commonly associated with Staph. aureus.
   d. CLPU is sometimes misdiagnosed as infectious keratitis.

9. Common findings associated with CLPU include:
   a. Gram-positive bacteria.
   b. Focal epithelial excavation overlying necrotic tissue.
   c. Subepithelial infiltrate.
   d. All of the above are associated with CLPU.

10. Which of the following is an inflammatory event that occurs with use of low Dk hydrogel materials for extended wear?
    a. Striae.
    b. Folds.
    c. Contact lens peripheral ulcer.
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Lessons Learned: Contact Lenses, Adverse Events and Bacterial Keratitis

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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Lessons Learned: Contact Lenses, Adverse Events and Bacterial Keratitis

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.
Contact lens-induced corneal hypoxic adverse events have always presented a great challenge for eye care practitioners. Insufficient oxygen to the cornea creates both short- and long-term physiological changes. Some of these corneal alterations are transient, such as endothelial blebs, edema, limbal injection, myopic creep, epithelial microcysts and epithelial thinning.1-5 Although these conditions tend to be reversible, they each resolve at differing rates. Examples of non-reversible complications include corneal vascularization, polymegathism and pleomorphism.6

Silicone hydrogel (SH) lenses, introduced in the late 1990s, were designed to decrease the risks of hypoxia-related complications. In 2001, Covey et al. determined that SH wear actually had the same physiological effects as not wearing a lens at all.7 A recent literature review suggests that SH materials have effectively eliminated hypoxia for most patients.8 Certainly, SH materials do eliminate hypoxia-induced complications, and while these materials make up the majority (64%) of the US contact lens market, there are still about 12 million people wearing either hydrogel lenses, GP lenses or hybrids.7,9

Advances in SH materials continue to occur, and these materials are available in sphere, toric and multifocal designs and in multiple replacement modalities. Custom SH lenses and hybrid lenses equipped with SH soft skirts are also available. Silicone hydrogels are also becoming more readily available for individuals with high ametropia. For conditions such as high astigmatism and individuals who do not adapt well to SH materials, hydrogels remain the only readily available soft lens option.

Previous-generation hydrogel materials still have a role in the market; however, individuals wearing these materials may be at increased risk for hypoxia-related complications. Additionally, a lens manufactured out of SH may give the practitioner a false sense of security about its ability to reduce or eliminate hypoxia.

PERMEABILITY VS. TRANSMISSIBILITY

The ability of oxygen to pass through a contact lens polymer has been evaluated with various techniques, each of which has limitations. These measures include equivalent oxygen percentage (EOP), oxygen flux, oxygen consumption and the measure most familiar to clinicians, oxygen permeability (Dk). Briefly, EOP is a measure of oxygen uptake rate of the cornea immediately after a lens is removed. Oxygen flux is the amount of oxygen that reaches the eye, while oxygen consumption is the amount of oxygen the cornea consumes under a specific condition.

With Dk, the diffusion coefficient (D) and the oxygen solubility (k) form an inherent oxygen permeability material property. The methodology of determining the Dk differs; however, each lens material does have a published Dk value provided by manufacturers.10

ABOUT THE AUTHOR

Dr. Zimmerman is an associate professor of clinical optometry at The Ohio State University College of Optometry. He has articles published in a number of journals, including Archives of Ophthalmology, Optometry, Human Factors and Ophthalmic Epidemiology.
A more critical value for the clinician is oxygen transmissibility (Dk/t). Transmissibility takes into account the thickness of the contact lens and is measured in units x 10^-9 (cm/s)/(mlO2/ml x mm Hg). Benjamin has referred to these units as Fatt Dk/t units (honoring the pioneering work of Irving Fatt in this field of study).11

**CRITICAL OXYGEN TRANSMISSIBILITY LEVELS**

The earth's atmosphere is 20.9% oxygen, and because the cornea is avascular, it receives the majority of its oxygen from the atmosphere, with lesser amounts received from the aqueous humor and limbal vasculature.12 The corneal tissues use oxygen at differing rates, with the epithelium metabolizing oxygen 10 times faster than the stroma.13 If a contact lens is placed on the cornea that does not allow an EOP of 20.9%, the cornea theoretically suffers from hypoxia and will thus experience physiological alterations. Brennan has evaluated oxygen flux, which is the volume of oxygen reaching an area of the corneal surface over a period of time.14,15 Numerous investigators have performed substantial research evaluating different theories on how oxygen traverses through a contact lens polymer. Others have evaluated EOP.16

However, much of the research has been dedicated to oxygen transmissibility and the Dk/t levels necessary to mitigate hypoxic stress. In 1984, Holden and Mertz found that a Dk/t of 24 was necessary to avoid corneal edema for daily wear, and a Dk/t of 87 was necessary for extended wear.17 Harvitt and Bonanno found Dk/t levels of 35 and 125 were necessary to avoid anoxia throughout the entire corneal thickness for open and closed eye conditions, respectively.18 Papas found that a Dk/t of 125 was necessary to avoid limbal injection.19 Morgan and Efron stated that Dk/t levels need to be approximately 20 and 33 for the central and peripheral portions of a soft lens, respectively, in order to avoid edema with daily wear.20 These Dk/t levels are summarized in figure 1.

**LENS TRANSMISSIBILITY**

Most manufacturers list Dk/t for specified lens powers. For instance, senofilcon A has a Dk of 103. At -3.00D, the lens has a published center thickness of 0.07mm, and the associated central Dk/t is 147. At +3.00D, the center thickness is 0.147mm, with a central Dk/t of 70. The initial value of 147 exceeds the original Holden-Mertz criteria of 87 in order to limit overnight corneal edema to approximately 4%, while the +3.00D fails to reach 87. Towards the edge of the optic zone (approximately 4mm from the optic center) of a +3.00D lens, the Dk/t will exceed 87. Contrary to a plus power lens, a high minus lens will have an increased thickness towards the optic zone edge, and therefore, depending on the power, may not be able to achieve the desired Dk/t of 87.

Using a Spectralis OCT (Heidelberg Engineering), figure 2 demonstrates the thickness profiles for various powers of balafilcon lenses. Since the lens thickness can dramatically change depending on power or design, such as the ballasting technique for toric lenses, central Dk/t is misleading. Benjamin has proposed that mean harmonic thickness may be a much more valid value, as it averages the radial thickness of the center and periphery of a lens.21

**TRANSMISSIBILITY WITH SPECIALTY LENSES**

The practitioner needs to pay much closer attention to the Dk/t for patients wearing latheable SH custom lenses, piggyback fits, scleral lenses and orthokeratology lenses. Custom SH lenses are currently being manufactured with efrosilcon A (Definitive; Dk = 60, Contamac US). Although this material is silicone hydrogel, it is oftentimes used for high ametropia, resulting in rather thick portions of contact lenses. An example is for the correction of keratoconus, which tends to require relatively thick soft lenses, typically ranging from 0.3mm to 0.6mm.22 Oxygen transmissibility with efrosilcon A will then range from 10 to 20 units. A Dk/t of 10 should theoretically result in corneal edema with daily wear; however, reports state that hypoxia-related complications with these lenses are actually quite rare. This may be due to the amount of lens movement associated with the blink, which allows for increased tear exchange with oxygen-rich tears.23 Piggyback fitting is often reserved for patients with irregular corneas who suffer from GP lens awareness, or to assist in stabilizing the GP lens. If the practitioner determines that a piggyback fit is the most appropriate

<table>
<thead>
<tr>
<th>Table 1. Currently Available GP Materials with Dk Value of 100 or Greater</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brand</strong></td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Boston X0</td>
</tr>
<tr>
<td>Boston X02</td>
</tr>
<tr>
<td>Optimum Extra</td>
</tr>
<tr>
<td>Optimum Extreme</td>
</tr>
<tr>
<td>Menicon Z</td>
</tr>
<tr>
<td>Paragon HDS 100</td>
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**REVISED CORNEA & CONTACT LENSES | JANUARY 2014 | 19**
option, extra attention must be paid to material selection. Ideally, the soft lens will be a low-plus SH that will provide acceptable transmissibility, while the GP lens should have a Dk of 100 or greater (Table 1).

Historically, the soft lens has been a low-powered plus lens, while a recent report suggests the use of minus-power lenses. Either way, the soft lens and GP should be of high Dk. The Dk/t of the piggyback system can be derived using an equation, which can be found below.26

Recently, there has been an increase in use of scleral lenses for irregular corneal conditions or ocular surface disease. These lenses provide good comfort, vision and therapeutic benefit with many ocular surface conditions. Unlike corneal GP lenses, scleral lenses rest on the conjunctiva and, if fit appropriately, will completely vault the corneal surface. The thickness of the corneal vault and the lack of tear exchange must be taken into consideration when assessing the risk of hypoxia with scleral lenses.

In 2012 Michaud calculated the theoretical oxygen transmissibility of scleral lenses in conjunction with the thickness of the tear reservoir.26 He proposed the following equation:

\[ \frac{Dk}{t} = \frac{1}{\tau \times Dk} \]

To perform this calculation, it is first necessary to know the Dk of the tears, which has been determined to be approximately 80.27 The center thickness of a scleral lens is related to its overall diameter (OAD). For instance, an 18mm OAD lens may have a center thickness of approximately 300μm, while a 24mm OAD lens may have a center thickness of 500μm. If a patient is wearing a lens with a 300μm center thickness and a Dk of 100 fit with a 250μm vault, the calculated transmissibility of the system would be 16.

This Dk/t would not meet the Holden-Mertz or Morgan et al. criteria, and in theory, this would put the patient at increased risk of corneal hypoxia. Michaud explains, however, that hypoxia-related complications with scleral lenses are fortunately not common events.

Soft lenses for orthokeratology fits should be manufactured out of high Dk GP materials. Typically, the Dk of these lenses is over 100. Using a thickness gauge, a sample of orthokeratology lenses yielded center thicknesses of approximately 200 to 220 microns. Therefore, the central Dk/t of a 100 Dk lens would be approximately 50. Using Menicon Z (Dk = 163) would yield a central Dk of approximately 80, which approaches the Holden-Mertz criteria. Fortunately, corneal edema is not commonly found in patients wearing ortho-K lenses.

### TABLE 1

<table>
<thead>
<tr>
<th>Fig. 1. Dk/t levels necessary to mitigate hypoxic stress.</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOP(^34)</td>
</tr>
<tr>
<td>Dk/t</td>
</tr>
<tr>
<td>&gt;18%</td>
</tr>
<tr>
<td>125 – Avoid limbal hyperemia per Papas18 &amp; to avoid full corneal anoxia with extended wear per Harvitt/Bonanno18</td>
</tr>
<tr>
<td>87 – Avoid corneal edema with extended wear per Holden/Mertz17</td>
</tr>
<tr>
<td>15-18%</td>
</tr>
<tr>
<td>35 – Avoid full corneal anoxia with daily wear per Harvitt et al.16</td>
</tr>
<tr>
<td>33 – Avoid full peripheral corneal edema with daily wear per Morgan et al.20</td>
</tr>
<tr>
<td>24 – Avoid corneal edema with daily wear per Holden/Mertz17</td>
</tr>
<tr>
<td>11-15%</td>
</tr>
<tr>
<td>20 – Avoid central corneal edema with daily wear per Morgan et al.20</td>
</tr>
<tr>
<td>&lt;6%</td>
</tr>
<tr>
<td>0 – PMMA</td>
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</tbody>
</table>

### Table 2. Currently Available Silicone Hydrogel Brands with Extended Wear or Continuous Wear FDA Approval

<table>
<thead>
<tr>
<th>Brand</th>
<th>Manufacturer</th>
<th>Dk</th>
<th>Replacement</th>
<th>Overnight Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Optix Night &amp; Day</td>
<td>Alcon</td>
<td>Dk = 140</td>
<td>Monthly</td>
<td>30 day CW</td>
</tr>
<tr>
<td>Purevision &amp; Purevision2</td>
<td>Bausch + Lomb</td>
<td>Dk = 91</td>
<td>Monthly</td>
<td>30 day CW</td>
</tr>
<tr>
<td>Biofinity</td>
<td>CooperVision</td>
<td>Dk = 128</td>
<td>Monthly</td>
<td>6 night/7 day EW</td>
</tr>
<tr>
<td>Air Optix</td>
<td>Alcon</td>
<td>Dk = 110</td>
<td>Monthly</td>
<td>6 night/7 day EW</td>
</tr>
<tr>
<td>Acuvue Oasys</td>
<td>Vistakon</td>
<td>Dk = 103</td>
<td>2 – Week</td>
<td>6 night/7 day EW</td>
</tr>
</tbody>
</table>
access to naraflon A (Dk/t @ -3.00D of 118), which was only recently made available in the US market. The year 2013 also saw the arrival of a new SH, the Dailies Total1 (Alcon). This novel material places SH (deleflicon A) in between high water content anterior and posterior lens surfaces, which creates a gradient water content lens. This lens has a Dk/t @ -3.00D of 156.

Although not a SH material, the Biotrue 1-Day, trademarked as a “Hypergel,” consists of 78% water-equivalent to the water content of the cornea. At -3.00D this lens has a Dk/t of 42.

All three of the previously discussed daily disposable lens materials offer Dk/t values that exceed the Holden-Mertz criteria for daily wear, and are indications that manufacturers are developing products that are intended to increase comfort and reduce hypoxia.

Silicone hydrogel and high Dk GP materials have been extremely important advances in contact lenses. Although these materials essentially eliminate adverse effects secondary to hypoxia, they have not been associated with a decrease in the incidence of microbial keratitis, and have actually been associated with an increased risk of infiltrative keratitis.21,23 Corneal hypoxic changes are becoming much less common; however, when fitting patients with high ametropia or a specialty fit, the clinician needs to be knowledgeable of the material Dk and the thickness of the lens or lens system.

Fig. 2. Thickness profile for soft contact lenses of various powers (A-D). Each image is half a spherical lens from the approximate optic center to the edge. Center thickness of the -3.00 DS lens is 70μm.

THE COMPROMISED EYE:
PRESENTATIONS AND PATHOLOGY
A visual guide to some of the worst complications of the anterior segment.
By Christine W. Sindt, OD

Complications of the cornea, such as microbial infections and allergic reactions, can present in a number of ways, and symptoms can vary from simple discomfort to vision loss in extreme cases. Due to the complexity of these presentations and the multitude of potential causes for each, it’s crucial to assess and diagnose the myriad complications in a timely manner in order to properly and promptly treat your patients. This photo gallery can help guide the way you handle these challenging conditions.

SUBCONJUNCTIVAL HEMORRHAGE
I like to tell my patients that everybody is allowed one subconjunctival hemorrhage in their lives. While these hemorrhages look terrible, they are actually benign. But when a patient presents with a subconjunctival hemorrhage, it could be an indication of a deeper problem. So, it’s important to ask the patient if they are taking blood thinners or have a blood disorder, such as leukemia.

If the patient has chronic subconjunctival hemorrhages or bruises elsewhere on their body, they should be worked up for blood dyscrasia. Patients are often beside themselves with worry over these hemorrhages, but the ocular presentation will not result in any loss of vision.

CORNEAL STAINING
These photos demonstrate just a few of the many different types of staining we see on the eye in clinical practice. The key to these photos is that the pattern of the staining indicates the specific pathology and illuminates the diagnosis. In the first case, there’s a visible line along the eyelids, indicative of lagophthalmos, while the patient in the second photo exhibits overall diffuse staining, which indicates a toxic event present in the eye.

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ENDOTHELIAL MORPHOLOGY

These photos display polymegathism (cells enlarging to take up the space of adjacent cells that died) and pleomorphism (cells that have changed their shape and are no longer hexagonal) changes as endothelial damage progresses. We are born with about 3500 endothelial cells per mm². Throughout the course of our lives, natural aging will cause some of these cells to die and drop off. In a normal, healthy adult, there are approximately 2500 endothelial cells per mm².

When we observe a drop to fewer than 800 cells per mm², the cornea becomes pathologic and experiences edema.

As doctors, even though we can’t count the number of cells present at the slit lamp, we must remember the importance of the endothelium and the overall functioning of the entire eye. It’s possible that we may put a contact lens on the eye that stresses the endothelium, accelerating the death of cells. Which particular contact lens we fit someone in at age 20 may have an impact on that person at age 80.

MICROBIAL KERATITIS

Microbial keratitis can be treated with broad-spectrum antibiotics. If the infection presents in a central location and threatens sight, a culture may need to be done. If the borders of the presentation are not round, or have an otherwise unusual presentation, we usually recommend culturing to determine the organism.

Unfortunately, it is usually not practical to do a culture prior to initiating therapy, so first start with broad-spectrum antibiotic.

If the keratitis doesn’t respond, culture the organism and adjust as needed. Often, doctors are afraid that if they begin with a course of antibiotics, it’ll throw off the culture results, but it’s important to keep in mind that most cultures are not going to come up positive, regardless of what we do. Timing of the culture will not generate a positive or negative reading—if you culture later on, and the organism is still active in the area; the culture will come up positive, regardless of antibiotic use.
**THE COMPROMISED EYE**

**GIANT PAPILLARY CONJUNCTIVITIS**
There are two forms of GPC: allergic and mechanical. Commonly, we think of GPC as being caused by an allergy—our body’s way of reacting to allergens by creating the papilla to get allergens out of eye. With the advent of SiHy lenses, we’ve actually started seeing mechanical GPC from the modulus of the lens causing rubbing on the tarsal plate, which causes focal GPC. This form is not allergic and cannot be treated as such. The only way to treat patients presenting with mechanical GPC is to remove the lens entirely.

**FILAMENTARY KERATOPATHY**
Filamentary keratopathy refers to mucin strands attached to corneal epithelial cells. This condition occurs in patients presenting with severe dry eye. Frequently, filamentary keratopathy will occur in the area of exposure. Symptoms of the condition can range from foreign body sensation to significant pain. The common treatment for patients with filamentary keratopathy is a bandage contact lens, but more severe cases will require tarsorraphy.

**DELEN**
This is an example of what can happen to a patient who presents with chronic dry eye. When the cornea is exposed to the environment and is not properly lubricated, the stroma will start to thin out. This thinning is referred to as dellen. In severe cases, it can perforate. It is not infectious and does not have to be treated as such. As indicated by the staining photo, there is no break in the epithelium into the stroma, and while there is surface dryness, the area over the dellen remains intact.

**CORNEAL EDEMA AND FOLDS UNDER SCAR**
This is a result of severe dry eye; the long-term nature and severity has caused not merely scarring but also a complete corneal breakdown. The resulting dysfunction...
of the endothelium causes corneal folds. This photograph illustrates the importance of getting any severe dry eye condition under control, as it can completely destroy the cornea if left untreated.

**ANTERIOR BLEPHARITIS/DEMODEX INFESTATION**

Demodex is a parasitic arachnid commonly found in the environment. Of the many species of Demodex, only two are present in humans, and they are not the same that live on pets. It is unknown how much the organism influences the course of pathology on the ocular surface; however, when there is significant blepharitis present, often there is also a significant Demodex population. Symptoms of Demodex are collarettes along the base of lashes, itching, poor tear film quality and ocular surface hyperemia.

**BLEPHARITIS**

Meibum is a vital component of the lipid layer of the tear film, which prevents evaporation. Inconsistency in meibum secretion due to blepharitis alters tear functionality, causing chronic dryness. Telangiectasia is a sign indicating chronic inflammation of the eyelid margin. This indicates that the blepharitic state has been there for a significant amount of time, and the margin is undergoing significant changes. If telangiectasia is observed, it is a clear sign of the chronicity of the blepharitis.

**ACANTHAMOEBA**

It’s important to observe a variety of Acanthamoeba presentations, because the condition itself often masquerades. Frequently, Acanthamoeba is not the first thing doctors think of; because of the condition’s subtle presentations, sometimes practitioners do not consider the condition at all. This is problematic if it delays diagnosis and the prompt initiation of therapy, further exacerbating the situation.
Ensuring our contact lens-wearing patients avoid complications is always one of our top priorities. A great number of factors can cause complications in these patients, ranging from dryness-related discomfort to toxicity reactions related to contact lens solutions. While preventing adverse events in contact lens wearers may seem like a difficult task, a standardized approach to reinforcing compliant behavior can go a long way in keeping them complication-free.

1. PRESCRIBE GAS PERMEABLE LENSES FOR EASIER COMPLIANCE.
I will typically recommend GP lenses to patients who are generally not good with handling or cleaning a soft lens. So, when dealing with your less-than-compliant patients, consider prescribing gas permeables. A rigid material is more amenable than a soft material to staying clean even with minimal patient effort.

Also, rigid lenses are much better for extended or continuous wear, as they are less susceptible to the tear film stagnation under the lens that allows any bioburden on the eye to remain, potentially causing an infection. The wear characteristics of rigid lenses enable greater flushing of tears with the blink than soft materials, which is one reason why GPs have the lowest complication and infection rates.

Some practitioners are reluctant to fit gas permeable lenses, given their reputation for less comfort than soft lenses, but once you put a GP lens on a patient they’ll actually realize how little sensation there truly is. A little effort at patient education helps prepare patients for the adaptation experience. I explain that rigid materials are sort of like a new watch or a new piece of jewelry—initially it will feel foreign, but after wearing it for a few days, you adapt to it and forget it’s there at all.

2. CHOOSE MODALITIES THAT PREVENT BUILD-UP OF BIOBURDEN.
Naturally, daily disposal is the ideal way to avoid complications that involve bacterial bioburden. However, when fitting a patient who wants to wear reusable lenses, it’s actually safer to fit them in an extended wear lens that they can wear for a month straight and then dispose of, rather than daily wear. Wearing the lens for a month straight without removing it actually helps to reduce bioburden by avoiding contact with the fingertips, as well as potentially poor patient cleaning habits.

Nevertheless, a shorter wear cycle is always the best choice. Daily disposable lenses have a complication or infection rate that is just as low as gas permeable modalities, making them an excellent option for avoiding complications. The longer a lens remains in contact with the ocular flora, the more likely it will pick up debris, particularly if a patient is not cleaning properly.

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3. PAIR MATERIALS WITH THE CORRECT CONTACT LENS SOLUTION.
Practitioners need to be aware of the differences between the many solutions on the market, as some lenses pair better with specific solutions than others. A good rule of thumb is to recommend a solution from the same manufacturer of the prescribed contact lens whenever possible, as they tend to work fairly well with one another.

Of course, some patients will have an allergic response to certain formulations, regardless of how well these products interact with each other. Sometimes, it’s simply a matter of experience—over time, you’ll learn which lenses work best with specific solutions. Educating yourself and your patients on how solutions pair with certain lenses will help to prevent adverse events as a result of a “bad match.”

4. AVOID GENERIC, STORE-BRAND SOLUTIONS.
Very often I will have patients come in complaining of irritation, which leads me to ask what lens solution they are using. They’ll often sheepishly tell me that they have made the switch to a generic, store-brand solution. Many of these solutions are based on a formulation that is approximately 25 years old that was made for the old pHEMA lens materials. These solutions are not ideal for use with silicone hydrogel lenses. Sometimes, the preservatives in these solutions will be absorbed or adsorbed to the lens and cause a toxicity reaction, leading to increased redness and irritation.

To remedy this, I give the patient a sample of the original solution I recommended and have them return in about a week. This procedure usually clears the problem up. This is why I stress educating the patient on the specific reasons I prescribed the original product, as most patients are unaware that generic solutions are inferior to the products we recommend.

5. SCHEDULE REGULAR FOLLOW-UP VISITS.
Patient follow-up visits are absolutely crucial when trying to eliminate adverse events. Allergic reactions in patients who have previously been exposed and sensitized to a particular preservative system will generally happen very quickly. On the other hand, patients who are contact lens “newbies” will take several months to experience a reaction.

For this reason, we need to get patients back for multiple follow-up visits, so that we can assess their progress. We really cannot give patients their lenses and care systems and then say, “Okay, you’re all set—see you next year!” It’s good to have patients come back after one week, one month and three months of wear, to see if there are any negative effects from either their lenses or solution.

If no problems manifest within that three-month span, you can then typically instruct your patients to come back for their routine annual visit. It is important to stress to patients that they should continue to come in for follow-up visits at least once per year. Our ocular and systemic systems constantly change, so it is important to assess these in regard to contact lenses over time.

6. KNOW WHO IS A GOOD FIT FOR DAILY DISPOSABLE LENSES VS. EXTENDED WEAR.
Generally, within the first month of wear, at the patient’s second follow-up visit you should be able to accurately assess whether they are a good fit for extended wear or short-cycle lenses. Young people, especially teenage boys, should be fit in shorter cycle lenses right off the bat, as they are typically not our most compliant patients.

Personally, I like to fit younger patients into daily disposables right away to get them into that habit as soon as possible. If patients are consistent with their wear schedules, the risk of developing adverse events is significantly lower. By properly matching appropriate wear schedules to each of our patients, we can do our best to take non-compliance out of the equation all
10 WAYS TO AVOID CONTACT LENS COMPLICATIONS

together, and avoid complications related to poor compliance.

7. THOROUGHLY REVIEW CONTACT LENS WEAR AND CARE PROCEDURES WITH YOUR PATIENTS.
As I’m sure you can imagine, many patients I see do not practice proper compliance. When I ask patients how they are cleaning their lenses, often I discover they are just taking them off and dunking them in solutions.

I always go over proper wear and care schedules with each of my patients, and give them detailed, written instructions on compliant behavior. I give my patients a handout, we go over the instructions, demonstrate everything and then I have them show me exactly what they’re supposed to do. When they come back for their first follow-up visit, I have them tell me how they are cleaning and caring for their lenses. If they aren’t able to explain it quickly, I know they’re not doing it right. In this scenario, we revisit how to properly care for the lenses and I give the patient another handout. Patient education is crucial in preventing complications in lens wearers, so be sure to stress proper compliance with each patient.

8. ADDRESS EXTERNAL OCULAR HEALTH BEFORE FITTING PATIENTS IN CONTACT LENSES.
During the initial visit, it’s important to look at the entirety of the health of the eye, including the lids and adnexa. Before fitting a patient in contact lenses, screen for meibomian gland issues or blepharitis. Ensure that every patient has healthy lids, and that they are free of any tear film problems.

If your patients do in fact have pre-existing complications, be sure to give them any remediation they need, such as a lid scrub or warm compress, before fitting them at a later date. Once you have ensured their external health is in order, it is then safe to begin fitting them into an appropriate contact lens.

9. PRESCRIBE DAILY DISPOSABLE LENSES FOR PATIENTS WITH DRY EYE.
It’s generally a good idea for dry eye patients to avoid extended wear lenses. Daily wear and daily disposable lenses help to decrease the risk of having any problems, especially those related to bioburden under the lenses.

Because tear stagnation under the lens is such a problem with extended wear modalities, drier eyes are not very conducive to the practice of sleeping with contact lenses in place. Build-up on lenses worn overnight with a drier tear film is typically higher. For these patients, it is best to avoid extended wear lenses entirely, and fit them into daily disposable modalities to prevent any potential complications.

10. RECOMMEND DAILY DISPOSABLES DURING ALLERGY SEASON.
When patients are experiencing irritation or discomfort as a result of allergies, very often patients can go into a daily disposable modality and then discard the lens very rapidly, so they don’t have to worry about any residual build-up of the allergen if they’re not cleaning properly. This will help to reduce redness, dryness and any other irritation that can be caused by allergies.

Keep in mind that it’s also important for all contact lens wearers to have a good, serviceable pair of glasses. If they have an allergic event, get the flu or just don’t feel like wearing their lenses, they will not be wholly reliant on their contact lenses, potentially exacerbating any issue the lenses may be causing.

While complications in contact lens wearers can be caused by numerous factors, following these tips can help avoid many common problems. Educating yourself and your patients on these complications and their many causes will help ensure that your patients maintain safe and comfortable lens wear.
Lessons Learned From FDA-Sponsored Research

When the FDA supports research concerning contact lens solution disinfection efficacy, clinicians should take notice. Three key themes emerged from its recent investigation into care product usage, published in Eye & Contact Lens in November 2012.¹⁻⁴

**1 Multipurpose solutions (MPS) are complex formulations,** and we ask a lot from them, including disinfection and comfortable lens wear. Not all MPSs are alike. MPSs contain different ingredients which interact with different contact lenses differently. Most MPSs contain POLYQUAD® and ALDOX® preservatives or polyhexamethylene biguanide (PHMB) preservative. As the FDA-sponsored research showed, the disinfection efficacy of a PHMB-based MPS (0.0001%, six-hour soak) was affected by the presence of a lens. However, the patient is likely unaware that there are differences in MPSs. Product confusion is common—generic formulations are often placed alongside branded systems in packaging of the same color and font. This is why it is important for eye care professionals to give a clear recommendation to both new and returning patients.

**2 Decisions should be data-driven whenever possible.** In the FDA-sponsored research challenging a PHMB solution with *Fusarium solani,* the authors noted that “consumers using PHMB-containing contact lens solutions and exhibiting poor contact lens hygiene (such as reuse or extended soak times) may reduce the fungicidal activity of these MPSs.”³ The same paper, while not studying the hypothesis, commented that “another concern is the potential for corneal epithelial cell damage and loss as a result of the subsequent release of the biocide (PHMB) onto the ocular surface once the lenses are placed back into the eye.”³ These authors also noted that “corneal epithelial cell loss or damage provides a breach through which microbes may enter.”³

Taken collectively, these findings underscore the need for more performance evaluations of MPS contact lens solutions.

The FDA developed a comprehensive research plan aimed at improving preclinical testing of contact lenses and their care products. The FDA designed experiments to evaluate “the physiochemical properties of silicone hydrogel lenses to determine whether subcategorization was necessary, and, if so, how it should be performed.”⁴ The FDA also sought to examine the anti-microbial effectiveness of an MPS in the presence of a contact lens in “real world” scenarios, and mentioned routine *Acanthamoeba* testing as a goal.⁴ These efforts will require a great amount of work from many experts, but provide a partial roadmap for the future contact lens and lens care testing.

It is important to remember that all studies have limitations and we should take care to avoid generalization about entire product categories. Just one product containing PHMB preservative and one product containing POLYQUAD®/ALDOX® preservative were studied—and we do not know the specific brands used. Nevertheless, it is noteworthy that biocidal activity of POLYQUAD®/ALDOX® in the presence of a contact lens was not adversely affected.

**3 Doctors must make specific product recommendations** and counsel patients to adhere to them. This requires practitioners to take greater responsibility for patient education regarding lens care. Doctors should spend time recommending the proper lens care for the lenses they prescribe—for instance, discouraging the “topping off” of solution in contact lens cases.

No single step will guarantee success, but a paradigm shift in which doctors exert more influence over their patients’ lens care habits will result in permanent changes in their behavior that help to foster long-term, uncomplicated, successful contact lens wear.

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One of the most challenging aspects of eye care is the patient who presents with a non-healing corneal wound. Because the etiology of this presentation is so diverse and complex, it presents both diagnostic and interventional challenges to clinicians at all levels of ophthalmic practice. In the debut installment of this new column devoted to corneal health, we’ll focus on how to differentially diagnose non-healing corneal wounds and how to treat such cases using appropriate therapeutic agents.

The most common causes of non-healing corneal wounds or defects are relatively simple, commonly seen conditions, but rarely are they readily attributed to the process. These include entities such as significant posterior lid disease and ocular surface disease in the form of moderate to severe dry eye, including the autoimmune conditions Sjögren’s syndrome, lupus, thyroid and rheumatoid disease.

Differentially diagnosing non-healing corneal wounds can sometimes be challenging, but if clinicians develop a standardized approach to assessing the history, ocular tissue and the response to intervention, arriving at an accurate diagnosis and implementing appropriate therapeutic care will be made easier.

**BLEPHARITIS**

While all clinicians routinely screen for this problem due to the frequency of occurrence, it is actually sometimes overlooked as a potential source of loss of epithelial integrity.

It is important that the lids be thoroughly assessed for inflammatory disease of an anterior etiology. It is even more important that they are assessed for significant posterior blepharitis with involvement of the meibomian glands. In patients who have complications secondary to a decrease in tear break-up time, an increase in evaporative tear film loss can show persistent epithelial defects when the remainder of the eye appears normal.

The treatment of this problem is directed toward improving posterior lid function, and most typically involves the use of oral doxycycline, or an equivalent treatment, such as minocycline. A significant change has been made in the treatment patterns relative to dosing and concentration, and in most circumstances clinicians have moved to a lower dose per day of 20mg to 50mg PO QD, as opposed to the more traditional 100mg PO BID that had previously been used.

The use of doxycycline to treat posterior lid disease is critical because it improves meibomian gland function, which directly impacts the causative problem responsible for the persistent epithelial defect. Other alternatives in the management of this condition involve the use of oral omega-3 fatty acids. The dosing ranges from 2000 to 3000mg per day, preferably a triglyceride formulation, as it offers increased absorption and bioavailability.

These treatment regimens can be prolonged in their response time and frequently need to be accompanied by adjunctive topical therapy in the form of non-preserved tears and non-preserved bland ointments. The goal is to create a healthier meibomian gland system that will be able to sustain normal epithelial physiology.

**ANTERIOR BASEMENT MEMBRANE DISORDER**

ABMD is one of the most common corneal dystrophies—so common, in fact, that it is frequently overlooked as a potential cause of non-healing epithelial defects. In cases of true ABMD, the diagnosis can be made via corneal topography, which is an excellent method of demonstrating irregular surface epithelium profile and allows clinicians to discern the presence of the underlying disease state. Alternatively, slit-lamp examination can be a helpful diagnostic technique, but is best performed with topical fluorescein to allow the irregular patterning of the corneal epithelium to be observed.

Treatment of ABMD as a cause of non-healing corneal defects is directed towards rehabilitation of the damaged tissue and the reduction of the propensity on the part of ABMD patients to have irregular wound healing (epithelial hyperplasia). In many instances, this requires intervention with debridement, a bandage lens, topical antibiotics and anti-inflammatories.

In individuals with reduced visual acuity due to ABMD and non-healing or poorly healing epithelial wounds, this treatment can be very effective. It is recommend that oral doxycycline therapy be added...
to the regimen in most patients who present with this concern, to decrease matrix metalloproteinase-9 induction and to block the development of collagenase, a mediator of poor wound healing in patients who present with persistent defects.

HERPES SIMPLEX
In differentiating corneal wound concerns, clinicians should always be vigilant for the presence of herpes simplex virus (HSV). As one of the three mimicking diseases, along with syphilis and Lyme disease, HSV is capable of affecting all ocular tissue.

HSV is typically insidious and, in most instances, diagnosed as a result of failure of more common interventions to produce successful results, with herpes becoming the de facto diagnosis. It is not uncommon for patients who present with HSV to have epithelial defects for weeks, if not months. Once initiation of oral antiviral therapy is instituted, the wound typically heals relatively quickly and responds favorably to interventional therapy.

In patients in which herpetic complications are suspected, the use of oral antiviral agents—typically Valtrex 500mg PO TID or acyclovir 400mg five times a day—is an appropriate initial dose to reduce the viral population and begin the wound resolution process. Additionally, topical adjunctives such as non-preserved tears and non-preserved ointments, including Refresh PM, DuoLube or Lacri-Lube, are frequently useful in the healing process.

TOXICITY
A typical associated finding is that the patient has been on topical agents such as antibiotics, nonsteroidals or others for weeks prior to the change in diagnosis.

It is important to remember that these agents can be very toxic, and are capable of dramatically slowing the wound healing process. This is particularly true of NSAIDs, which have a well-established history of impacting wound healing. As a result, NSAIDs should be avoided in all circumstances in which non-healing epithelial lesions are present.

Treatment for non-healing corneal defects as a result of toxicity varies from completely discontinuing the culprit drug to markedly reducing the dosing concentration of the topical agents. In addition, one should implement a regimen designed to support the corneal epithelium in the form of non-preserved tears and ointments. This method can be complemented with an oral agent such as doxycycline to decrease the inflammatory process and stromal involvement by blocking collagenase development.

Epithelial insults that are secondary to toxicity typically respond very rapidly to discontinuation of the toxic agents and the institution of the bland regimen designed to promote epithelial healing. Rarely is it the case that a cornea made toxic by topical therapy takes as long as weeks to months to heal. Patients who have that type of response may possibly have underlying systemic issues, such as diabetes, herpes and ABMD.

NEUROTROPHIA
Neurotrophic corneas are one of the most challenging clinical presentations at any level of ophthalmic care: complex in etiology and frequently difficult to diagnose.

Neurotropia implies that the normal cycle of epithelial stimulation of the 5th cranial nerve to produce epithelial cell regeneration has been interrupted and the area of the cornea involved has a decreased level of epithelial cell production that begins to show initially an epithelial defect and then eventually stromal involvement, which can result in perforation if allowed to progress.

The treatment of neurotrophic disease can be extremely complex. In all instances other than those in which the patient had allergies to the primary therapy, use a full dose (100mg PO BID) of doxycycline during the acute phase. Additionally, the use of a bandage contact lens can be extremely helpful in treating the underlying disease state, and in many instances will be sufficient to bring the patient back to a normal epithelial presentation, as it blocks the evaporative loss that is part of the process of epithelial cell damage.

Non-preserved topical therapy administered adjunctively at a rate of q8h to q2h is appropriate. The patient also needs to be managed carefully with office visits on a regular basis in the initial treatment period to assure that the lesion is responding favorably. In some patients, the neurotrophic lesions are non-responsive, and as a result, require greater interventional management.
Although soft contact lenses have eclipsed gas permeables in popularity and in the public consciousness, over three million people in the United States alone currently wear GP lenses.¹ It is a modality with many unique strengths that, when paired with the proper encouragement, stands to gain rather than diminish in prominence. GP lenses provide crisp, clear vision for a wider variety of patients than do soft lenses. Advances with newer, larger diameter designs have significantly improved lens comfort and stability.

These improvements have given practitioners the opportunity to select a GP lens option as the first choice for many contact lens patients. However, to set the stage for success, it is important to discuss some common concerns that patients may report—or, worse, not report to you but worry about nonetheless.

1. COMFORT
"My friend tried hard contact lenses and they said they hurt. A lot."

One of the main reasons GP lenses are not commonly prescribed or worn is their reputation for discomfort. Practitioners and patients alike tend to share the same fear that reduced comfort will lead to patient dissatisfaction with the experience.

Prospective contact lens patients may have asked their friends and family about the different contact lenses they have used in the past. It is not uncommon for patients to request a type of lens recommended by someone they know and trust. Patients especially tend to remember which lenses they do not want to try; unfortunately, GP lenses get a bad rap for discomfort.

One of the best ways to reduce discomfort is to use anesthesia when fitting GP lenses by instilling one drop of topical anesthetic before applying the lens to the eye. Using this technique, many patients are often so impressed with the vision achieved with their new lens that the feeling of lens awareness becomes less of an issue.² It is important to inform the patient that the lens will not feel quite as good as the initial dispensing, and their eyes will get used to this type of lens the more often they wear it.

Another way to increase the comfort of GP lenses is the use of topical nonsteroidal anti-inflammatory drops. NSAIDs reduce prostaglandins, which effectively reduces pain.⁶,⁷ A typical dosing regimen involves instilling one drop of NSAID 30 minutes, 15 minutes and right before GP dispensing, and then one drop one hour after insertion.⁶ Repeat this regimen for three to five days until gas permeable lens wear adaptation is complete.⁷

Another useful tip is to discuss the GP wear and adaptation experience with the patient before the lens is applied to the eye, so they know exactly what to expect. A common statement from the practitioner can be, “This type of lens will be similar to a new watch or a new ring. At first, you’ll notice it’s there, but the more and more you wear it, the less you’ll feel it. At some point, you even forget you have it on.” Patient education is very important in the success of GP lens wearers.

"I wore hard contact lenses in 1970s and they were really uncomfortable. What’s changed since then?"

Patients that have worn “hard” lenses in the past may have been wearing PMMA or early RGP lenses, but it is hard to pinpoint exactly which type of lens they wore, as both were frequently used. Recent advances in lens materials, such as the fluorosilicone acrylates, allow much more oxygen transmissibility than previously available materials.³

GP lenses are now available in ultra-thin designs with aspheric peripheries, which aid in comfort.

ONE OF THE MAIN REASONS GP S ARE NOT COMMONLY PRESCRIBED OR WORN IS THEIR REPUTATION FOR DISCOMFORT.
as well. Be sure to inform patients that newer lens materials deliver much more oxygen to their eye, and the design of these lenses is much thinner and more comfortable than their old lenses.

2. STABILITY
“Sometimes when I’m riding my bike, one of my lenses pops off or feels really unstable!”

Some of the smaller, corneal GP lenses may dislodge if a patient moves their eye in an extreme left/right gaze, plays sports, etc.

Lens dislodgement can occur with some of the smaller diameter lenses, especially if there is any inferior standoff. This is especially true in GP wearers who have irregular astigmatism or more challenging fits. If the patient wishes to remain in a corneal GP design, increasing the diameter of the lens or changing the peripheries of the lens may aid in centration.

The larger diameter lenses are much less likely to dislodge than the corneal GP lenses due to decreased lid interaction and the ability to completely vault the cornea and rest on the sclera/conjunctiva (figure 1). Corneal-scleral, mini-scleral and scleral lens designs are great options for patients with complaints of lens dislodgment. Newer designs are becoming easier to fit, which gives the practitioner more confidence when fitting patients in GP lenses.

3. PRICE
“So, Doc, you’re telling me the price of one GP contact lens is $. But I only pay $ for a box of my current soft contact lenses. And what if I don’t like them or they don’t work?”

Another major concern for patients is the cost of GP lenses. Oftentimes, they experience sticker shock at the initial price of the lens, and typically have reservations about the success of the lens fit.

Although the initial price of GP lenses may be more expensive, the long-term cost actually can work out to be less with this modality. Because GP lenses are far more durable and resistant to deposits than soft lenses, many patients are able to successfully wear the same pair for one year or longer. In fact, 47% of patients who wear GP lenses replace their lenses after two to three years.

Working with a lab that has a good warranty program is essential in building trust with your GP patients. If patients are worried about the success of the lens—and committing their money to it—some communication of the cost should be addressed. “I understand your concern about the cost of the lens, but this lens has a great warranty,” you might say. “We can make any changes necessary in a short period of time to get the most accurate prescription and fit. At the end of the trial period, if you still do not like the lenses, we can return them for a full or partial refund and go back to your original lenses.”

Addressing the issue of returning the lens and going back to what the patient was already wearing gives the patient more confidence in taking the leap and trying a GP lens, as there is little to no risk involved.

Practitioners should not be apprehensive about GP lenses, but we should be aware of the concerns that may arise with any type of contact lens. Knowing the pros and cons of soft, GP and hybrid lenses will allow us to make the best selection for each patient. By addressing and managing concerns with GP lenses, most patients will be able to achieve crisp, comfortable vision while maintaining ocular health.

What Do You Do?
Shift your focus from what you ‘do’ to what you ‘can do’ for your patients when marketing your practice.

A recent plane ride started just as every other one does: wait in a line that was much longer than it needed to be, hope to find a place to stuff my carry-on, take out my iPad and headphones and pray the person sitting next to me doesn’t show up. Unfortunately, they always do.

Once they arrive, the usual verbal drill goes something like this: “You flying back home or going to Dallas for work?” The next volley of pleasantries inevitably centers on occupation. The question, “What do you do?” is a staple of more than half of my flights. When I respond with my stock answer, “I’m an optometrist,” I invariably get these two follow up questions: (1) What do you think of laser surgery?, and (2) Exactly which eye guy are you? Are you the doctor guy or the other one?

IN-FLIGHT ENTERTAINMENT
In an effort to circumvent this boring song and dance, on my last flight I decided to shake things up a bit. This time, my answer to the question, “What do you do?” was, “I have the best gig in the world. Ten to 20 times per day, I get a chance to change someone’s life for the better, and let them experience the world in ways they never thought they could.”

The response was, “Wow! But what do you do?”

“I just told you what I do,” I replied.

“I meant, what’s your occupation?”

“Oh, I fit contact lenses. I’m an optometrist,” I said.

“Really? I wear contact lenses and none of that happened to me.”

“That’s because you didn’t get your lenses from me.”

Yes, this dialogue is nearly verbatim, and I was purposely being overly dramatic just to see what would happen. As you can probably imagine, the discussion quickly turned to new types of contact lenses, as well as all of the recent changes in our industry. That was certainly a nice change of pace from the typically boring in-flight conversation, but this interaction actually taught me a very powerful lesson.

When talking to patients, or in our marketing to prospective patients, we usually talk about what we do instead of what we can do for our patients. There’s a significant difference between saying, “We fit contact lenses” and, “We help you see better and experience life more fully when we fit you with contact lenses.”

It’s the age-old marketing adage of explaining the WIIFM (What’s in it for me?), but in this case, it’s about specifically delineating and clearly stating the benefits of what we do. It takes practice to break the habit of simply stating, “I’m an optometrist,” when you feel the reflexive urge to respond with only your title.

Have some fun with your staff (like we did with a client’s) and come up with occupational WIIFMs for other jobs before your staff begins to work on their own. Here are some of my favorite WIIFMs from a few different professions:

“I ensure that the commerce, economy and traffic of the state of New Jersey continues to function at optimum efficiency.” – Toll collector on the Garden State Parkway

“We make the world a prettier place to live by helping sustain and cultivate nature.” – Landscaper

“I make sure you have an energetic start to each day.” – Dunkin’ Donuts store manager

“We bring you non-stop entertainment and keep you plugged in to the news of the world.” – Cable guy

“We make you happy.” – Veterinarian (note that it does not say something along the lines of, “We make sick dogs better.”)

SPREAD THE WORD
Once you settle on your own “what you do” statement—and please, feel free to use mine—practice it with some office role-playing. Sure, it will feel acutely foreign at first, but once you get comfortable with the script and essence of your WIIFM, you should start using it with both current and prospective patients. When it becomes a more natural part of your approach, you’ll find that you actually start looking forward to hearing the question, “What do you do?” Unless, of course, you’re on an airplane.

“OH, I FIT CONTACT LENSES. I’M AN OPTOMETRIST,” I SAID.
Drifting down the Nile stretched out on a silk pillow, fanned by the breeze of a thousand hummingbirds.

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Indicated for vision correction for daily wear (worn only while awake) or extended wear (worn while awake and asleep) for up to 30 nights. Relevant Warnings: A corneal ulcer may develop rapidly and cause eye pain, redness or blurry vision as it progresses. If left untreated, a scar, and in rare cases loss of vision, may result. The risk of serious problems is greater for extended wear vs. daily wear and smoking increases this risk. A one-year post-market study found 0.18% (18 out of 10,000) of wearers developed a severe corneal infection, with 0.04% (4 out of 10,000) of wearers experiencing a permanent reduction in vision by two or more rows of letters on an eye chart. Relevant Precautions: Not everyone can wear for 30 nights. Approximately 80% of wearers can wear the lenses for extended wear. About two-thirds of wearers achieve the full 30 nights continuous wear. Side Effects: In clinical trials, approximately 3-5% of wearers experience at least one episode of infiltrative keratitis, a localized inflammation of the cornea which may be accompanied by mild to severe pain and may require the use of antibiotic eye drops for up to one week. Other less serious side effects were conjunctivitis, lid irritation or lens discomfort including dryness, mild burning or stinging. Contraindications: Contact lenses should not be worn if you have: eye infection or inflammation (redness and/or swelling); eye disease, injury or dryness that interferes with contact lens wear; systemic disease that may be affected by or impact lens wear; certain allergic conditions or using certain medications (e.g. some eye medications). Additional Information: Lenses should be replaced every month. If removed before then, lenses should be cleaned and disinfected before wearing again. Always follow the eye care professional’s recommended lens wear, care and replacement schedule. Consult package insert for complete information, available without charge by calling (800) 241-5999 or go to myalcon.com.

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

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• FDA-approved for up to 30 days and nights of continuous wear**
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