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- The Effects of Friction and Lubricity on Comfort
- Introducing Water Gradient Technology
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FEATURES

14 The Shifting Prescribing Paradigm
By Jason J. Nichols, OD, MPH, PhD
Learn why so many practitioners now choose daily disposables as their go-to lenses.

19 Dealing With Discomfort
By Caroline A. Blackie, OD, PhD, FAAO, Donald R. Korb, OD, FAAO, and Kelly Nichols, OD, MPH, PhD, FAAO, Dipl PH
An in-depth look at the epidemiology, diagnosis and treatment of contact lens-related dryness.

25 Clinical Relevance of Contact Lens Lubricity
By Desmond Fonn, MOptom, FAAO
Using science to provide better comfort for CL wearers.

28 Measuring Friction and Lubricity of Soft Contact Lenses: A Review
By Lakshman N. Subbaraman, PhD, BSOptom, MSc, FAAO and Lyndon W. Jones, PhD, FCOptom, FAAO
Comfort may be tied to friction and lubricity.

34 Introducing Water Gradient Technology
By Ralph Stone, PhD
Daily disposable contact lenses with water gradient technology represent a new era in contact lens wear.

40 The Development of Dailies Total1 Water Gradient Contact Lenses
By John Pruitt, PhD and Erich Bauman, OD, FAAO
Research led to a departure from using a single bulk material for the whole lens.

46 Groundbreaking Technology Debuts in Daily Disposable Market
Panelists discuss a unique new lens that has surprising characteristics designed to defeat discomfort.

DEPARTMENTS

5 Editor’s Perspective
By Jason J. Nichols, OD, MPH, PhD
Daily Disposable Prescribing Finally Begins to Trend Up

6 Research Review
By Eric Papas, PhD, MCOptom, DipCL
Close to the Edge: Oxygen at the Lens Periphery

10 Prescribing for Presbyopia
By Thomas G. Quinn, OD, MS
Daily Disposables: Problem Solver for the Presbyope

11 Contact Lens Design & Material
By Neil Pence, OD, FCOptom
Novel Water Gradient Lens Material

12 Dry Eye Dx and Tx
By William Townsend, OD, FAAO
How Daily Disposable Lenses Can Address Contact Lens Dryness

13 Contact Lens Care & Compliance
By Susan J. Gromacki, OD, MS, FAAO
Compliance With Daily Disposable Contact Lenses

53 Contact Lens Practice Pearls
By Jason Miller, OD, MBA, FAAO
Setting the Stage for Daily Disposable Contact Lenses

54 The Business of Contact Lenses
By Gary Gerber, OD
Winning the Race

55 Pediatric and Teen CL Care
By Christine W. Sindt, OD, FAAO
Why Daily Disposable Lenses Make Sense for Children

56 Treatment Plan
By William L. Miller, OD, PhD, FAAO
Contact Lens Discomfort: Can Past Workshops Provide Insight?
THIS IS WHY contact lenses have reached a new era in comfort.

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*In vitro measurement of unworn lenses.
2. Based on critical coefficient of friction measured by inclined plate method. Significance demonstrated at the 0.05 level. Alcon data on file, 2011.
3. In a randomized, subject-masked clinical study, n=40. Alcon data on file, 2011.

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Daily Disposable Prescribing Finally Begins to Trend Up

As noted in our annual report for 2012, published in the January 2013 edition of Contact Lens Spectrum, the daily disposable segment of the contact lens market was the segment of the contact lens market associated with the most growth for the second year running. This is indeed exciting news, particularly as the United States market has lagged behind other worldwide markets for many years in terms of daily disposable prescribing trends. It seems that practitioners here are beginning to embrace the notion that daily disposables are associated with the best comfort, convenience and ocular health in terms of the individual contact lens-wearing experience.

As you will note in this Special Edition of Contact Lens Spectrum, we are on the verge of seeing an even greater revolution in the daily disposable segment of the market. Innovation, rather than incremental advances in product development, is what drives market-leading advances and adoption of new ideas and technologies. As you will see in this issue of Contact Lens Spectrum, we are now seeing an entirely new material technology being used in the daily disposable platform. It’s only to be anticipated that new technologies such as this will further drive trends we observe in clinical practice. We hope you enjoy this Special Edition on daily disposable contact lenses and associated new material technologies as you consider adopting new prescribing trends in your practice.
Close to the Edge: Oxygen at the Lens Periphery

In the days before silicone hydrogel materials became available, contact lens practitioners spent a great deal of time worrying about oxygen transmissibility (Dk/t). These concerns seem to have faded into the background in recent years, but should we forget about the issue altogether? In a silicone hydrogel world where daily wear is the dominant modality, and — apart from blinking — there is no eye closure during lens wear, are there still risks?

Measuring Dk/t: Location Matters

Manufacturers specify the Dk/t of their contact lens materials based on measurements taken at the center of a representative lens, usually a lens with a nominal back vertex power of −3.00D. For any prescribed lens, however, the thickness profile can vary significantly from the center to the periphery, depending on the design and the back vertex power. Even for a −3.00D spherical lens, the thickness can be 2 or 3 times greater at some positions outside the center.

Because the Dk/t of a lens is governed by its thickness, we need to pay closest attention to the regions of the ocular surface covered by the thickest portions of the lens. For most modern lenses with diameters of 13.5 mm to 14.5 mm, the peripheral cornea and the limbus are likely to be the main sites under threat.

Corneal Swelling Response to Hypoxia

Perhaps the most commonly studied response to ocular hypoxia is corneal swelling. Swelling is less pronounced at the periphery of the cornea than at the center because anatomical factors progressively limit the extent to which swelling can occur as we approach the limbus. For this reason, there is little value in measuring the far periphery of the cornea, but some studies have examined slightly less extreme locations.

One such investigation showed that certain features of a hydrogel lens, such as thickened toric stabilization zones, can limit oxygen flow and cause regional and localized swelling under daily wear conditions (Tyagi et al, 2010). Another study, which may have more general application, found that after 3 hours of open eye wear, spherical lenses with lower oxygen transmissibility can produce significant peripheral swelling (Morgan et al, 2010). These researchers analyzed their data to estimate the minimum Dk/t needed to avoid peripheral corneal swelling in daily wear. They calculated a value of 33 × 10⁻⁹ (cm s⁻¹)(mLO₂ mL⁻¹ mm Hg) across the entire lens.

Because most practitioners do not routinely use pachometry in daily practice, corneal swelling is not useful as a clinical indicator of the oxygen supply to the corneal-limbal region. The most easily accessible alternative marker is the behavior of the limbal vasculature.

Hyperemia as an Alternate Marker

Blood vessels throughout the body respond to the level of oxygen in their local environment, and those at the limbus are no exception. In the short term, reduced oxygen causes hyperemia, which is perceived as ocular redness or limbal flush. Although these changes are reversible, prolonged periods of hyperemia can lead to vascularization of the peripheral cornea, which is a more serious condition with the potential for permanent consequences.

One of the earliest observations made with what were then experimental silicone hydrogel lenses was that eyes remained whiter-looking (Papas et al, 1997). Until then, we believed that mechanical irritation from the lens edge caused the redness habitually associated with soft lenses. Later experiments using goggles filled with different gas mixtures demonstrated that oxy-
gen is an important factor mediating these responses (Papas, 2003). In addition, a number of studies have confirmed the value of silicone hydrogels in avoiding limbal redness (Du Toit et al, 2001; Dumbleton et al, 2001; Maldonado-Codina et al, 2004; Brennan et al, 2006; Dumbleton et al, 2006).

From a clinical standpoint, the amount of redness produced by a contact lens is inversely related to the oxygen transmissibility at its periphery (Papas, 1998); however, the minimum transmissibility required to prevent hyperemia from occurring remains a subject of active debate. Thus far, the only work that has directly addressed this question suggested a Dk/t in the lens periphery of about 55 x 10^-9 (cm s^-1)(mLO2 mL^-1 mm Hg) as a reasonable minimum target for the open eye (Morgan et al, 2010). The peripheral transmissibility of this lens was 36 x 10^-9 (cm s^-1) (mLO2 mL^-1 mm Hg), a value that potentially lowers the transmissibility requirement somewhat and is similar to the value I mentioned earlier for peripheral corneal swelling.

Silicone Hydrogel and the Redness Response

Of some relevance is a study that compared the limbal redness responses of two silicone hydrogel lenses with that of a conventional hydrogel lens during daily wear (Maldonado-Codina et al, 2004). Although the silicone hydrogel lenses were made from materials of dissimilar oxygen permeability, the results showed that, on average, they caused minimal amounts of redness that were similar in magnitude to the hyperemia observed in the non-lens-wearing control subjects. Eyes wearing the conventional hydrogel lenses were significantly redder than those wearing either of the two silicone hydrogel lenses.

Although the researchers in the 2004 study did not try to determine a transmissibility threshold for limbal redness, their observations were subsequently interpreted as evidence that the amount of oxygen transmitted by the silicone hydrogel lens with the lower Dk/t was sufficient to prevent a vascular response in the open eye (Morgan et al, 2010). The peripheral transmissibility of this lens was 36 x 10^-9 (cm s^-1) (mLO2 mL^-1 mm Hg), a value that potentially lowers the transmissibility requirement somewhat and is similar to the value I mentioned earlier for peripheral corneal swelling.

Consider These Qualifying Issues

Before accepting this conclusion regarding minimum oxygen transmissibility, however, we should consider two qualifying issues. First, this estimate of oxygen transmissibility (Morgan et al, 2010) was made some years after the original clinical observations (Maldonado-Codina et al, 2004) by measuring a lens with a power of −3.00D. Lenses in the study ranged from −1.00D to −4.00D, so the single value would not have equally represented the experience of all participants.

Second, the peripheral thickness measurement for the reference lens in the 2004 study was made at a diameter of 8 mm. Although this was appropriate in the context of the study’s primary aim, which was to examine corneal swelling, it does not correspond to the area of the lens that would influence vascular changes at the limbus. Thus, more data must be accumulated to satisfactorily resolve the uncertainty surrounding these numbers. Regardless of the precise values, it seems clear the open eye is not immune to the effects of hypoxia that may occur from a contact lens that has poor oxygen-transmitting properties. Fortunately, clinicians can avoid this problem by choosing carefully from the array of contemporary lenses that are available. CLS

For references, please visit www.clspectrum.com/references.asp and click on document SE2013.

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From a clinical standpoint, the amount of redness produced by a contact lens is inversely related to the oxygen transmissibility at its periphery.
SIMBRINZA™ Suspension provided additional 1-3 mm Hg IOP lowering compared to the individual components1

- IOP measured at 8 AM, 10 AM, 3 PM, and 5 PM was reduced by 21-35% at Month 3-4.
- Efficacy proven in two pivotal Phase 3 randomized, multicenter, double-masked, parallel-group, 3-month, 3-arm, contribution-of-elements studies2,3.
- The most frequently reported adverse reactions (3-5%) were blurred vision, eye irritation, dysgeusia (bad taste), dry mouth, and eye allergy1.
- Only available beta-blocker-free fixed combination2,3.

INDICATIONS AND USAGE
SIMBRINZA™ (brinzolamide/brimonidine tartrate ophthalmic suspension) 1%/0.2% is a fixed combination indicated in the reduction of elevated intraocular pressure (IOP) in patients with open-angle glaucoma or ocular hypertension.

Dosage and Administration
The recommended dose is one drop of SIMBRINZA™ Suspension in the affected eye(s) three times daily. Shake well before use. SIMBRINZA™ Suspension may be used concomitantly with other topical ophthalmic drug products to lower intraocular pressure. If more than one topical ophthalmic drug is being used, the drugs should be administered at least five (5) minutes apart.

IMPORTANT SAFETY INFORMATION
Contraindications
SIMBRINZA™ Suspension is contraindicated in patients who are hypersensitive to any component of this product and neonates and infants under the age of 2 years.

Warnings and Precautions
Sulfonamide Hypersensitivity Reactions—Brinzolamide is a sulfonamide, and although administered topically, is absorbed systemically. Sulfonamide attributable adverse reactions may occur. Fatalities have occurred due to severe reactions to sulfonamides. Sensitization may recur when a sulfonamide is readministered irrespective of the route of administration. If signs of serious reactions or hypersensitivity occur, discontinue the use of this preparation.

Corneal Endothelium—There is an increased potential for developing corneal edema in patients with low endothelial cell counts.

Severe Hepatic or Renal Impairment (CrCl <30 mL/min)—SIMBRINZA™ Suspension has not been specifically studied in these patients and is not recommended.

Adverse Reactions
In two clinical trials of 3 months' duration with SIMBRINZA™ Suspension, the most frequent reactions associated with its use occurring in approximately 3-5% of patients in descending order of incidence included: blurred vision, eye irritation, dysgeusia (bad taste), dry mouth, and eye allergy. Adverse reaction rates with SIMBRINZA™ Suspension were comparable to those of the individual components. Treatment discontinuation, mainly due to adverse reactions, was reported in 11% of SIMBRINZA™ Suspension patients.

Drug Interactions—Consider the following when prescribing SIMBRINZA™ Suspension:
Concomitant administration with oral carbonic anhydrase inhibitors is not recommended due to the potential additive effect. Use with high-dose salicylate may result in acid-base and electrolyte alterations. Use with CNS depressants may result in an additive or potentiating effect. Use with antihypertensives/cardiac glycosides may result in additive or potentiating effect on lowering blood pressure. Use with tricyclic antidepressants may blunt the hypotensive effect of systemic clonidine and it is unknown if use with this class of drugs interferes with IOP lowering. Use with monoamine oxidase inhibitors may result in increased hypotension.

For additional information about SIMBRINZA™ Suspension, please see Brief Summary of full Prescribing Information on adjacent page.
Brinzolamide 1% - In clinical studies of brinzolamide ophthalmic suspension 1%, the most frequently reported adverse reactions reported in 5% to 10% of patients were blurred vision and bitter, sour or unusual taste. Adverse reactions occurring in 1 to 5% of patients were brinzolamide ophthalmic suspension, headache, dizziness, dryness, mouth, dryness, epiphora, eye fatigue, hyperemia, conjunctivitis, keratopathy, kidney pain, lid margin crusting or sticky sensation, nausea, pharyngitis, heating and urticaria.

Brinzolamide 0.25% - In clinical studies of brinzolamide ophthalmic suspension 0.25%, adverse reactions occurring in approximately 10% of the subjects included conjunctival injection, itching, facial and periorbital edema, hyperemia, tearing, head and eye pain, red eye, and reduced visual acuity. In descending order of incidence, corneal staining or erosions, photophobia, eyelid edema, abnormal visual acuity, blurring of vision, burning sensation, foreign body sensation, injection, irritation, tearing, and vision disturbances were noted.

Discontinuation of treatment due to adverse reactions has been reported in children and adolescents under 12 years of age. Adverse reactions reported in children and adolescents under 12 years of age included conjunctivitis, keratitis, iritis, and vision disturbances.

OVERDOSAGE - Although no human data are available, it has been noted that the toxic effects of brinzolamide are not likely to be severe as the drug is rapidly excreted in the urine and is not highly fat-soluble. The toxic effects of brinzolamide may include hypotension, bradycardia, and respiratory depression. In the event of an overdose, supportive measures and treatment for hypotension, bradycardia, and respiratory depression should be initiated. There is no specific antidote for brinzolamide overdose.

PARENT COUNSELING INFORMATION - Advise parents that the use of brinzolamide may cause mild effects such as a change in vision or slight discomfort. In the event of an overdose, supportive measures and treatment for hypotension, bradycardia, and respiratory depression should be initiated. There is no specific antidote for brinzolamide overdose.

POTENTIAL FOR VASCULAR INSUFFICIENCY - Brinzolamide may cause decreased intraocular pressure and increased risk of angle-closure glaucoma. Brinzolamide may also decrease the intraocular pressure and increase the risk of angle-closure glaucoma.

CONTAMINATION OF Topical Ophthalmic Products After Use - There have been reports of contamination associated with the use of multiple-dose containers of topical ophthalmic products. These containers have been inadvertently contaminated by patients who, in most cases, had a concurrent corneal disease or a disruption of the ocular mucocutaneous surface. (see Patient Counseling Information)
Daily Disposables: Problem Solver for the Presbyope

Daily disposable lenses may be ideal for adolescents and occasional contact lens wearers (Wagner et al, 2011; Efron et al, 2012), but there’s another population that’s ideal for daily disposable wear: presbyopes. Though well suited for occasional wear due to specific lifestyle requests (e.g. “I just want contact lenses for social occasions and when I work out”), presbyopes are great daily disposable lens candidates for other reasons.

Physiological Rationale
It has been well established that contact lens-related dryness is often a partner on the path to presbyopia (Moss et al, 2008). Meibomian gland dysfunction (MGD), which becomes more prevalent as we age (Hom et al, 1990), has been found to be associated with contact lens-related dryness (Young et al, 2012). MGD reduces the lipids available to the tear film, promoting more rapid tear break-up, and resulting in a relatively drier lens surface that accumulates deposits more quickly. This surface spoilage leads to reduced contact lens comfort, episodes of “foggy” vision, and ultimately contact lens dropout.

In Control
Presbyopes may lack ocular vigor, but many have financial independence. When presented with the indisputable case of how daily disposable lenses can improve their quality of life, many presbyopes decide on the spot to go with your recommendation.

Money Talks
When discussing the cost of contact lenses, we break out material fees from our service fee. Material fees are set to be competitive with online contact lens sources. When presenting material costs, be sure to factor in manufacturer rebates, which can be as much as $85 to $100. Also remind patients that, with daily disposable lenses, there’s no need to buy contact lens care solutions. This cost savings helps offset the expense of materials.

A Little Philosophy
We believe daily disposable lenses are a great option for virtually all contact lens wearers, so we recommend daily disposable lenses to most patients. We assess a lower service fee to fit daily disposable lenses as opposed to what we charge for 2-week or monthly replacement lenses. We feel good about this approach because:
1. It encourages patients to choose the daily disposable option
2. Patient response to daily disposable lenses is almost universally positive. As such, we generally spend less time managing these patients.
3. When all is said and done, we’re still making more profit by prescribing daily disposable lenses than we’d earn fitting 2-week or monthly lenses.

Make a Recommendation
The final key to success with daily disposable lenses is to make a firm recommendation for this modality. If you believe, as I do, that daily disposables are the way to go for most patients, state that with confidence. Most patients appreciate clear guidance.

Everybody’s Happy
Daily disposable lenses provide patients with a healthy option in soft lens wear. When pursued, your office benefits from happy patients and higher profit margins.

When presented in the right way, everybody wins with daily disposables! 

For references, please visit www.clspectrum.com/references.asp and click on document SE2013.
Novel Water Gradient Lens Material

The introduction of a new daily disposable contact lens may signal the need for a new category of lens material. The Dailies Total1 contact lens (Alcon), which was launched in various European markets during the past year, is the first water gradient soft contact lens. What’s unique about this lens is that the water content is not constant throughout the lens, but rather it changes from the main body or core of the lens to the surface. Here’s a brief overview of the key characteristics of this material and the water gradient phenomenon.

**Novel Water Content Properties**

Dailies Total1 lenses are manufactured from a new material, delefilcon A, using a modification of Alcon’s Lightstream Technology, the manufacturing process used to produce the Dailies Aqua Comfort Plus daily disposable contact lens. At the core of the Dailies Total1 contact lens, which comprises just over 90 percent of the lens, is a silicone hydrogel material with a water content of 33 percent. The surface of the lens is designed with a water content of over 80 percent. The change in water content and lens structure occurs fairly rapidly in the outer 5 percent of the lens on both sides or surfaces.

Oxygen transmissibility, lens modulus or stiffness and the resultant effect on handling, and lens-fitting characteristics are properties determined by the core of a contact lens. With its 33 percent water content core, the Dailies Total1 lens has the highest oxygen transmissibility of any daily disposable lens on the market. It has a Dk of 140 and a Dk/t of 156 for a –3.00D lens with a center thickness of 0.09 mm.

Wettability, lubricity or low coefficient of friction, the ability to resist deposits or soiling and overall biocompatibility with the ocular surfaces are key characteristics of a contact lens surface. A water content of over 80 percent at the surface should result in a wettable, lubricious lens.

**Winning Combination**

With U.S. Food and Drug Administration clearance already secured, 2013 will see the introduction of Dailies Total1 lenses in the United States. The advent of this novel new contact lens material with gradient water content properties and the benefits it may bring will be eagerly awaited. The high oxygen transmission of a silicone hydrogel lens with the surface advantages of a high water content at the surface should be a winning combination for an ever-growing number of patients wearing daily disposable contact lenses.

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Dry Eye Dx and Tx

How Daily Disposable Lenses Can Address Contact Lens Dryness

Despite advances in soft contact lens materials, design and surface characteristics and improvements in care solutions, discomfort and dryness lead many patients to stop wearing their lenses.

What Studies Tell Us
In a multisite clinical study, researchers investigated potential causes for contact lens discontinuation (Young et al, 2002). They found the majority of patients who discontinued lens wear (51 percent) did so because of discomfort, and the most commonly reported type of discomfort was dryness (40 percent).

More recently, researchers surveyed 4,207 contact lens wearers to determine why they stopped wearing their lenses (Dumbleton et al, 2013). Forty percent of the patients surveyed had discontinued lens wear for at least 4 months. The most commonly reported reasons for discontinuation were discomfort (24 percent) and dryness (20 percent).

Dryness and Discomfort
Patients experiencing contact lens dryness may report various symptoms, such as discomfort, irritation, burning, stinging, foreign body sensation and visual blurring (Sindt 2007), which may be caused by poor prelens tear stability, lens material or lens deposits. Contaminants begin to adhere to a lens surface within minutes of application (Brennan and Coles 2000), and the degree and type of deposits are influenced by the water content, ionic properties and silicone content of a lens. Because lens deposits decrease prelens tear film breakup time, they may exacerbate the sensation of dryness (Sindt 2007).

Lipids can significantly affect contact lens wear, and our appreciation of their function and impact on the ocular surface and contact lenses has expanded over the last decade (Panaser and Tighe 2012; Pucker and Nichols, 2012). For example, we have learned a lipid coating increases over time, and the aqueous tears cannot form a stable layer over a lipid-coated contact lens (Brennan and Coles, 2000).

Multipurpose contact lens solutions are designed to remove deposits, but they are never 100 percent successful in doing so (Brennan and Coles, 2000). In addition, improper lens care may leave some deposits on the lenses, leading to poor comfort and vision. Wu et al (2010) found that many patients wearing daily wear lenses exhibited poor hand hygiene and inadequate lens and storage case cleaning and had difficulty remembering when to return for aftercare.

Banish Deposits Daily
How can we help patients continue to wear their lenses comfortably when they have dryness or comfort issues? One option is to prescribe daily replacement lenses.

Daily disposable lenses may reduce the risk of noncompliance and complications associated with surface deposits, thus improving comfort and the total lens-wearing experience for patients.

Fahmy and colleagues (2010) refitted symptomatic patients who replaced their lenses at intervals of 1 to 4 weeks into Dailies AquaComfort Plus lenses. At the end of 4 weeks, they found statistically significant improvements in symptoms as well as in limbal and bulbar redness and conjunctival staining. CLS

For references, please visit www.clspectrum.com/references.asp and click on document SE2013.

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Compliance With Daily Disposable Contact Lenses

Daily disposable contact lenses represent a growing segment of the soft lens market in the United States, where they now comprise 17 percent of all fits and refits. Their usage is even greater overseas, where they represent roughly 35 percent of contact lens sales in Europe and 55 percent in Asia (Nichols, 2012).

These statistics shouldn’t be surprising, since daily disposables offer convenience, particularly for part-time wearers and people who travel and they provide new-lens comfort every day. In comparison with frequent replacement (2 weeks or more) daily disposable lens wear has been shown to minimize lens deposition and tarsal abnormalities and provide better subjective vision and overall satisfaction (Solomon et al 1996).

What’s more, daily disposable lens wear eliminates the need for care solutions and with them, the possibility of preservative uptake and release from lens care products. It also eliminates the need for a lens storage case, a potential source for contamination. Perhaps the most important benefit of daily disposable contact lenses is the elimination of concern regarding compliance with lens care required with reusable lenses.

Replacement Compliance

Many practitioners have difficulty monitoring how closely their patients follow their lens wear and replacement instructions. When questioned, many patients, especially part-time lens wearers, have difficulty remembering how frequently they replace their lenses.

A peer-reviewed paper by Dumbleton et al (2010) presents substantive data on compliance rates with soft contact lens replacement frequency. The researchers analyzed responses from 2,232 patients wearing silicone hydrogel and daily disposable lenses in North America. They found that those who wear daily disposable contact lenses reported the highest rates of compliance. In the United States, patients wearing daily disposables said they “always” replace their lenses as recommended by the manufacturer 82 percent of the time, as compared with 34 percent for 1-month lenses and 25 percent for 2-week lenses. When factoring out patients whose practitioners instructed them to replace the lenses less frequently than the manufacturer recommends, the compliance rates for lens replacement were 88 percent for daily disposables, 73 percent for monthly lenses and 48 percent for biweekly lenses. What do these numbers mean for our patients?

Good compliance means cleaner lenses, which ultimately should help reduce the incidence of many contact lens-related complications. On the other hand, there is more to compliance than just replacement. For daily disposable lenses, overnight wear and re-use without disinfection are perhaps of the greatest concern.

Complications Minimized

Chalmers and colleagues (2010) reviewed the records of 1,276 soft lens wearers, representing 4,120 office visits and found no significant correlation between daily disposable lenses and inflammatory or infectious events. More recently, in a carefully controlled evaluation of 166 symptomatic soft contact lens related corneal infiltrative events, use of daily disposable lenses was found to be protective (over 12x) in comparison to reusable lenses (Chalmers 2012).

Although compliance alone will never completely safeguard patients from the potential of complications, it is clearly a step in the right direction. Daily disposable lens wear provides the practitioner and patient with the most compliant-friendly way to wear contact lenses.

For references, please visit www.clspectrum.com/references.asp and click on document SE2013.

Dr. Gromacki is a diplomate in the American Academy of Optometry’s Section on Cornea, Contact Lenses and Refractive Technologies and practices in Chevy Chase, Md.
The Shifting Prescribing Paradigm

Learn why so many practitioners now choose daily disposables as their go-to lenses.

By Jason J. Nichols, OD, MPH, PhD

Daily disposable contact lenses have come a long way since their introduction in the 1990s, owing to advances in material composition and manufacturing processes. These lenses are recognized by patients and eye-care professionals not only for their convenience but also because they’re a healthy option. The rising appreciation of this modality is evidenced by increasing prescribing frequency worldwide, even in the United States, where practitioners have been slow to embrace this modality. In this article, I discuss the reasons why daily disposable contact lenses are challenging other modalities for the top prescribing spot in many practices.

New-lens Comfort Every Day

Despite many years of research and implementation of various clinical management approaches and algorithms, dryness and discomfort with contact lens wear persist. In one study, 79 percent of lens wearers reported ocular discomfort, and 77 percent reported varying degrees of dryness. Non-lens wearers also reported significant increases in late-day ocular discomfort, visual changes, soreness and irritation. What’s more, symptoms of ocular discomfort and dryness are the primary reasons why patients become dissatisfied and stop wearing their lenses. Overall comfort and end-of-day comfort remain elusive goals.

Daily disposable contact lenses provide a fresh, clean surface each day, and a clean lens surface can be expected to enhance comfort.
Cost Effective for Part-time Wear
The cost of daily disposable contact lenses has been considered a primary barrier to prescribing this modality. In fact, a 2011 Quick Poll by Contact Lenses Today showed that cost is the number one reason (58 percent) why eyecare practitioners don’t prescribe daily disposables [Oct. 23, 2011]. A recent study found that daily disposables can, indeed, be cost-effective for part-time wearers.

Efron and colleagues examined the cost-per-wear of daily, 2-week and monthly replacement lenses. They estimated the annual cost of professional fees, care solutions and lenses and divided that sum by the number of times the lenses are worn per year. They assumed patients were fully compliant with their wearing schedules and lens care and that they would make the most cost-effective purchases of lenses and care solutions. The study showed that the cost-per-wear of daily disposable spherical lenses is lower than for reusable spherical lenses when worn from 1 to 4 days per week. At 5 days of lens wear per week, the cost-per-wear is virtually the same for all three spherical lens replacement frequencies, and at 6 or 7 days of lens wear per week, the cost-per-wear of daily disposables is higher.

Although some lens wearers and practitioners may perceive daily disposable lenses as more costly, this study found that part-time wearers may receive the additional benefit of a less expensive modality with improved convenience. A 2012 Quick Poll by Contact Lenses Today showed that 76 percent of respondents believe daily disposable contact lenses are more convenient than 2-week and monthly replacement lenses [Nov. 11, 2012].

Improved Compliance, Fewer Complications
Eye health is of utmost importance to all of us, which is yet another reason to consider prescribing daily disposable lenses. In a 2010 Quick Poll by Contact Lenses Today, 89 percent of respondents believed the daily disposable modality is associated with a general reduction in contact lens-associated complications [Dec. 19, 2010]. Thus, the daily disposable modality may play an important role in promoting ocular health with contact lens wear, and there may be several reasons for this.

In a recent Web-based survey, contact lens wearers reported low compliance in hand-washing, lens-wearing times, rubbing and rinsing lenses, topping off solutions and lens case cleaning. None of the respondents wearing planned replacement or daily wear soft lenses or GP lenses reported total compliance; however, 8.9 percent of U.S. daily disposable lens wearers reported full compliance in all behaviors.

In another study, researchers found that practitioners were more compliant in prescribing the manufacturer’s recommended replacement schedule for daily disposable lenses than for 2-week replacement lenses. Similarly, patients were more likely to adhere to the recommended replacement schedule for daily disposable lenses than for 2-week replacement lenses. In other studies that compared patients wearing daily disposables with those wearing conventional daily lenses or frequent replacement lenses, those in the daily disposable groups had lower complication rates.

Although one study found an increased risk of...
microbial keratitis with some daily disposable lenses — a somewhat perplexing finding — a more recent study found daily disposable wear to be highly protective against symptomatic corneal infiltrative events.\textsuperscript{11} Although daily disposable lens wear still requires proper hand-washing and compliance with daily replacement, this modality has eliminated the need for cleaning, disinfecting and storing lenses. Perhaps the removal of these steps has helped to improve compliance.

**A Good Fit for Kids**

Children can be successful contact lens wearers,\textsuperscript{12-14} and they report significantly higher satisfaction with their quality of vision when wearing contact lenses as opposed to eyeglasses during sports participation.\textsuperscript{15} Similarly, children who wear contact lenses report significantly higher self-perception of their physical appearance and social acceptance than those of the same age who wear eyeglasses.\textsuperscript{16} Studies specifically examining daily disposable lenses and children found high success rates.\textsuperscript{12-14} The children in these studies demonstrated good vision, good ocular health with no significant complications, and excellent lens-handling skills. Most of the children and their parents reported high levels of satisfaction with contact lens wear. The majority of wearers preferred contact lenses over spectacles for vision, comfort and their appearance.\textsuperscript{13} In addition, having a back-up supply of daily disposable lenses is helpful for children, who may lose or damage their lenses more often than adults.\textsuperscript{14}

Because daily disposable lenses don’t require cleaning and disinfecting, they may be of particular benefit to children.\textsuperscript{14} While careful hand-washing and diligent attention to prescribed wearing times and follow-up visits remain important responsibilities for children and parents, daily disposable lenses may provide a convenient and consistently clean option.

**Prescribing Rates on the Rise**

According to an international survey, daily disposable lenses, while not as widely prescribed as 1- and 4-week replacement lenses, have gained popularity in the countries surveyed (Australia, Canada, Japan, The Netherlands, Norway, the United Kingdom, and the United States).\textsuperscript{17} Although they are especially popular in Japan, Norway and the United Kingdom, this survey found a significant increase in the prescribing rate for daily disposable lenses in the lesser prescribing countries (Australia, Canada, The Netherlands and the United States), especially in the last 3 years of the survey (2006 to 2008). Also of note in this survey, daily disposable lenses were worn more often by men, part-time wearers and patients who were slightly younger than those wearing reusable soft lenses.

Newly released data from 40 countries during the period 2007 to 2011 show daily disposable lenses are gaining in popularity and now represent nearly 25 percent of the soft lenses prescribed in these countries.\textsuperscript{18} According to this study, daily disposables are most frequently prescribed in Japan and parts of Northern Europe. According to these researchers, cost appears to be the most significant factor in prescribing daily disposable lenses, and they found a relationship between a country’s gross domestic product (basically, a measure of average wealth of individuals in a nation) and frequency of daily disposable fittings. In general, the countries with a higher income were associated with more daily disposable fittings. One notable exception was the U.S. market. Although the United States was among the top five countries for gross domestic product, it ranked 29th out of 40 countries for proportion of daily disposable fittings.\textsuperscript{18} Despite this puzzling finding, optimism for the growth of daily disposable lenses remains high in North America.

More recent data for the United States indicate that for the past few years, daily disposable lenses have enjoyed the highest yearly percentage growth rates of almost all categories.\textsuperscript{19} Data from the Contact Lens Spectrum Annual Report 2012 show that when compared with other modalities, such as 2-week replacement or quarterly replacement lenses, the daily disposable category showed substantial gains in 2012.
The prescribing rates for daily disposables are trending upward, and the benefits of daily disposables make that an easy trend to understand.

United States between January and September 2012 when compared with the same time period in 2011.\(^\text{19}\)

Trend information for daily disposables for 2013 also appears positive. Data from a *Contact Lens Spectrum* survey regarding anticipated use for the coming year reveals that 64 percent of respondents expect to prescribe silicone hydrogel daily disposables, and 52 percent expect to prescribe hydrogel daily disposable lenses more frequently in 2013.\(^\text{19}\)

When comparing data from 2011 and 2012 for Europe, Japan and the United States, daily disposables exhibited the highest growth rates in the U.S. market.\(^\text{19}\)

Finally, a 2012 Quick Poll\(^\text{4}\) by Contact Lenses Today showed that 44 percent of respondents believe daily disposables will dominate the contact lens market in the next few years [Oct. 28, 2012]. These trends suggest that practitioners and patients are realizing the benefits of the daily disposable modality.

### Understandable Trend

Daily disposable contact lenses are available with an extensive array of vision-correcting capabilities in numerous lens materials and a wide range of parameters. The prescribing rates for daily disposables are trending upward, and the benefits of daily disposables make that an easy trend to understand.

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### References

If your presbyopic patients aren’t experiencing clear binocular vision, they may not be in AIR OPTIX® AQUA Multifocal contact lenses.

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References:
1. In a randomized, subject-masked clinical study at 20 sites with 252 patients; significance demonstrated at the 0.05 level; Alcon data on file, 2009.
3. In a randomized, subject-masked clinical trial at 6 sites with 47 patients; significance demonstrated at the 0.05 level; Alcon data on file, 2008.
4. Based on a third-party industry report, 12 months ending October 2012; Alcon data on file.

See product instructions for complete wear, care and safety information.
Despite years of research and discovery, contact lens-related discomfort (CLD) remains highly prevalent, with an estimated 50 percent of U.S. lens wearers affected. Wearers frequently report general symptoms of dryness and discomfort, as well as specific complaints, such as grittiness and itchiness.

A study involving patients in the United States and Canada found that 79 percent of contact lens wearers reported discomfort, and 77 percent reported dryness. Together these symptoms represent the number one reason why patients stop wearing their contact lenses, which is particularly significant when we consider that about 3.5 million people start wearing contact lenses each year, but approximately 2 to 3 million established lens wearers discontinue lens wear each year.

Recognizing symptoms is relatively straightforward for clinicians, but identifying signs can be challenging. In a recent study, 23 percent of soft lens wearers with self-reported dryness showed no signs upon clinical examination using various standard tests. Furthermore, no single sign — significant corneal staining or reduced tear meniscus height, for example — was present in the majority of lens wearers.

This study supports the findings of previous studies: Symptoms, even when significant, frequently do not correlate with ocular signs. Young and colleagues also reported that some contact lens-related findings appear to be common among these patients, such as poor lens wetting, rapid tear breakup times and higher levels of deposits on lenses. They also found that asymptomatic individuals consistently report longer average comfortable lens-wearing times and less end-of-day discomfort. In contrast, patients with dryness symptoms reported, on average, 3.9 to 4.3+ hours of uncomfortable lens wear per day.

**Epidemiology of CLD**

Researchers have determined that more women than men have CLD, but the reasons for the higher prevalence among women are not fully understood. Some have hypothesized that hormones may play a role or that women are more likely to report symptoms.

Studies reveal interesting information about age and contact lens wear. Richdale and colleagues, who correlated contact lens dropout with ocular discomfort and dryness, found in their study that older patients (by ap-
proximately 9.5 years) and those who had started contact lens wear at a later age (approximately 4 to 5 years later) were more likely to stop wearing contact lenses.

As we would expect, contact lens wearers bothered by symptoms will decrease wearing time and eventually discontinue lens wear. In a cross-sectional survey of 730 people, the permanent discontinuation rate was 24 percent, and a more recent survey of more than 4,000 Canadian patients found that about 23% of those surveyed had discontinued contact lens wear permanently.

In our experience, some patients who have stopped wearing contact lenses, as well as some current lens wearers who have significant discomfort or visual symptoms, feel their quality of life has decreased, because many appreciate the improved vision and self-perception of physical appearance while wearing contact lenses.

Mechanisms Underlying Contact Lens Discomfort

Over the past 10 years, numerous mechanisms have been identified as key contributors to dryness in contact lens wearers.

- **Altered Tear Film**: Wearing a contact lens can produce a spectrum of ocular changes, including increased reflex tear secretion, deprivation of the wiper action of the lids over the covered ocular surfaces, elevated tear osmolarity and increased mucus production by non-goblet cells in the tarsal conjunctiva. As first reported by Tomlinson, however, the most important factor influencing discomfort with contemporary contact lenses is increased evaporation from the lens and ocular surfaces. The importance of prelens humidity was clinically demonstrated when 30 minutes of 100 percent humidity improved the prelens lipid layer thickness and comfort of hydrogel lenses.

- **Lens Wettability**: A key factor in the biocompatibility of a contact lens is the tear film’s ability to adequately cover and maintain its integrity over the lens surface. Unfortunately, the surface of a contact lens lacks the mucus-attaching properties of the cornea and the ocular surfaces and is not well equipped to secure the foundational mucus layer(s) essential for forming all layers of the tear film. Thus, the tear film over the contact lens cannot duplicate the characteristics of the tear film over the cornea.

With contact lens wear, the lipid layer is rarely equivalent to the usual lipid layer of the tear film in thickness or other characteristics. Therefore, the rate of evaporation increases, tear film constituents denature on the lens surface and, in combination with the thinner pre- and post lens tear films, friction between the cornea and the contact lens, and the lid wiper and the contact lens is inevitable with resulting discomfort.

- **Corneal Desiccation**: Because contact lens wear increases evaporation of the tear film, water is drawn from the tear film, thinning the post lens tear film. Consequently, the cornea may desiccate beneath a thin, high water content lens, leading to corneal epithelial defects and generalized discomfort.

- **Lid Wiper Epitheliopathy (LWE)**: When associated with contact lens wear, LWE in otherwise suitable contact lens wearers is most likely a result of the altered characteristics of the tear film between the lens and the lid wiper, compromising lubrication. An inadequate lipid layer is believed to play a significant role. Without adequate lubrication, the anterior surface of the contact lens is presented to the lid wiper at a rate on average of 12 to 15 blinks per minute, thousands of times a day. This activity can cause physical trauma, mechanical abrasion and inflammation of the epithelial cells of the lid wiper, resulting in symptoms of discomfort. Without an adequate lubricating layer, the lid wiper becomes a primary source of discomfort with contact lenses.

- **Giant Papillary Conjunctivitis (GPC)**: With the increased use of disposable contact lenses, particularly daily disposables, GPC is less of an issue today, but it still may occur. Generally, it is related to the difficulty in keeping the lenses wet and clean. With compromised wettability or a buildup of deposits, the friction/trauma applied by the lens to the palpebral conjunctiva escalates, as does the likelihood of GPC.

- **Blinking**: Blinking is critical for wetting the ocular and contact lens surfaces, maintaining the lipid layer and minimizing evaporation, yet it is often overlooked in the clinical examination of a patient presenting with symptoms. Forceful blinking helps increase the lipid layer thickness, presumably by augmenting the expression from the meibomian glands. Contact lens wear affects the blink rate and amplitude, frequently inhibiting proper blinking and further exacerbating the detrimental effects of the contact lens on the tear film.

- **Meibomian Gland Dysfunction (MGD)**: The blink is considered the primary mechanism for expressing oil from the glands, thus chronically reduced blink rate and amplitude, which are frequently observed with contact lens wear, can result in a reduced meibomian gland function and secretion output within hours. MGD may lead to significant
symptoms of ocular discomfort with contact lens wear. Reduced meibomian gland secretion contributes to contact lens discomfort, because evaporation from the tear film increases. This may initiate the cascade of LWE, which may further inhibit blinking. Similarly, if MGD develops during contact lens wear, discomfort may develop.

Although the mechanisms involved in ocular dryness associated with contact lens wear are numerous and complex, we know that MGD may well be the leading cause of dry eye and the most common cause of contact lens intolerance. These facts play an important role in diagnosing and managing CLD.

Diagnostic Aids

To appreciate the numerous tests required to evaluate the ocular surface, we must understand the effects of a contact lens on the eye. Even on a healthy ocular surface and tear film, a contact lens disrupts normal tear physiology through multiple mechanisms. For example, it will:

- Increase prelens tear film thinning and breakup time
- Alter and thin the lipid layer
- Increase evaporation.

In addition, the edge of a contact lens introduces physical and rheological challenges, including those resulting from meniscus formation. The surface of a contact lens and adherent material may also traumatize the ocular and conjunctival surfaces and present immunological challenges. Thus, a thorough assessment of the patient’s symptom history, including management successes and failures, as well as a complete evaluation of the ocular surface, the eyelids, the blink and the interaction of the contact lens with the tear film and ocular environment is important for successful contact lens wear.

The following tests are often used in clinical practice:

- **Questionnaires**: The Contact Lens Dry Eye Questionnaire, the Standard Patient Evaluation of Eye Dryness (SPEED) questionnaire or other surveys that ask about frequency and intensity of symptoms and late-day dryness may reveal important information.

- **Tear Film Breakup Time**: Measured before contact lens application and generally performed with fluorescein, an average of two or more readings in seconds should be taken with the biomicroscope. Tear film breakup time can also be measured using the Keratograph 5M (Oculus Inc.).

- **Corneal Staining** (fluorescein): Extent and location graded from 0 to 4.

- **Conjunctival Staining** (lissamine green): Extent and location graded from 0 to 4.

- **Bulbar, Limbal and Eyelid Margin Hyperemia**: Graded from 0 to 4.

- **Palpebral Conjunctival Evaluation**:
  - Hyperemia, roughness, papillary response graded from 0 to 4.
  - GPC graded from 0 to 4.

- **Lid Wiper Epitheliopathy**: Graded from 0 to 4.

- **Meibomian Gland Evaluation**:
  - Function (e.g., oil availability upon light pressure).
  - Secretion quality graded from 0 to 4.
  - Appearance (e.g., orifice capping, telangiectasia, etc.).

- **Meibography**: Graded from 0 to 4; can be performed via transillumination or with a meibographer.

- **Blink Completeness**

- **Tear Osmolarity**: Scores greater than 307 mOsm/L indicate dry eye.

- **Contact Lens Surface Wettability**: Graded from 0 to 4.

- **Schirmer or Phenol Red Thread Test**: Recorded in mm/min. or seconds.

For more insights, see “Clinical Patterns Aid Assessment.”

What Are We to Do?

While some patients experience CLD symptoms only in certain environments, such as the extremely low humidity in an airplane, others experience severe and constant symptoms that lead to termination of contact lens wear. Thus, while we can choose from numerous management strategies, we must be mindful that each patient is unique, and a tailored medical management approach, including ocular surface and lid assessment or if indicated, temporary or permanent cessation of lens wear, may be necessary. Treatment options include the following:

- **Adjust Ambient and External Environment**: Increased periocular humidity can have a dramatic and positive effect on the prelens tear film and contact lens comfort. Experiments with goggles to control evaporation have demonstrated decreased evaporation of the tear film thinning rates and reduced corneal epithelial erosions.

These results continue to affirm what we know is the key to increasing ocular comfort during contact lens wear: a robust tear film with an adequate lipid layer and a healthy blink mechanism. A tear film that is adequate or marginally adequate without a contact lens may not be adequate in the presence of a contact lens.
lens. Work environment, room humidity, outdoor humidity/aridness and drying environments (heating/air conditioning) all play a role and can be discussed with patients. Indoor humidifiers and appropriate placement of computer monitors in the workplace can have a noticeable impact on a contact lens patient’s comfort and may be important in the overall management plan.

- **Recommend Rewetting Drops:**
  Rewetting drops may help relieve symptoms of dryness and improve for some individuals however, patients may view them as inconvenient if they must use them frequently. Numerous brands of contact lens rewetting drops are available to consumers. We believe eyecare professionals should recommend a specific product, including instructions for use.

- **Change Lens Replacement Interval:**
  Patients with CLD may benefit from replacing their lenses more frequently. When compared with frequent replacement (1 to 3 months) and 2-week replacement lenses, daily disposable hydrogel lenses showed fewer lens surface deposits, and wearers reported better comfort and overall satisfaction. Daily disposable hydrogel lenses may also help alleviate end-of-day dryness symptoms.

- **Change Lens Material:**
  Certain polymers and surface treatments provide better wettability and a more normal prelens tear film than others. Refitting soft lens wearers who have CLD symptoms into silicone hydrogel materials may improve comfort. A study found that patients who had CLD symptoms and were wearing soft lenses experienced significantly improved dryness and comfort, and they increased their comfortable wearing time after they were refit with a silicone hydrogel material. In addition, we have found that patients may be more comfortable with a lower modulus silicone hydrogel lens, or even a conventional hydrogel lens, if they find a higher modulus silicone hydrogel lens uncomfortable. Additional recent studies have concluded that mechanical properties, such as the coefficient of friction of a lens, surface lubricity and lens stiffness are properties driving lens comfort. For instance, we know that a contact lens wearer will blink thousands of times a day, leading to a repeated mechanical interaction between the eyelid and contact lens surface and edge. There has been at least one study that has showed that a contact lens wearer has a reduction in the number of functional meibomian glands than non-lens wearers. One implication that the authors make is that the mechanical interaction between the lids and contact lens surface may lead to an atrophy of some of the meibomian glands. Thus, it seems reasonable to look at material characteristics such as coefficient of friction to help reduce the mechanical interaction and frictional drag between the lens and the lid as much as possible.

- **Change Care Regimen:**
  When contact lens wearers complain of discomfort, practitioners often change contact lens disinfecting solutions. Researchers have found a particular brand of multipurpose solutions (MPS) may provide improved overall and end-of-day comfort and overall satisfaction for a lens wearer when compared to other MPS brands. Changing a patient’s care regimen from an MPS system to a hydrogen peroxide-based system may result in longer comfortable lens wear times. As with many aspects of clinical practice, each lens wearer responds differently to each solution. Therefore, an individualized approach may be necessary to find the most appropriate lens care solution.

- **Discuss Essential Fatty Acid Supplementation:**
  Patients with CLD have reported improved symptoms of dryness and increased overall comfort, and they have demonstrated improved tear meniscus height while using omega-3 and omega-6 dietary supplements.
Adding to the CLD Armamentarium

Our understanding of CLD has advanced during the past several years. We can now direct our efforts toward alleviating these symptoms to multiple areas: new lens polymers, 1-day lenses, lens care products and methods to prevent evaporation, treatments for LWE, and, most importantly, the treatment of the meibomian glands to improve their secretion by various methods. With current treatments and new advances still in the pipeline, the future appears promising for reducing discomfort so that our patients can wear their contact lenses long term.

References

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The Clinical Relevance of Contact Lens Lubricity

Using science to provide better comfort for contact lens wearers.

By Desmond Fonn, MOptom, FAAO

Despite advances in contact lens materials, designs and lens care products, discomfort, especially end-of-day discomfort and dryness, continues to be the predominant reason for discontinuation of lens wear.\textsuperscript{1,2} Although much effort has been put into development of effective multifocal soft contact lenses, contact lenses to control myopic progression and attempts to decrease corneal infection rates, the most effective way to increase the number of wearers is a corneo-mimetic contact lens surface that provides outstanding end-of-day comfort and therefore significantly reduce the number of dropouts from contact lens wear.

Most soft lenses are fully hydrated and comfortable upon insertion. We know however that for many lens wearers comfort decreases or dryness worsens during the day\textsuperscript{3-5} and the maximal fluid state of the ocular environment and conventional hydrogel and silicone hydrogel lenses can change\textsuperscript{6-8} after insertion. So the challenge for polymer scientists, mechanical engineers and everyone else associated with material and lens development, is how to prevent loss of water from the lens surface and therefore the bulk, or more appropriately how to effectively make the surfaces truly biocompatible. Some manufacturers have claimed to achieve some of these objectives described further in this article, but before that it is worth describing some of physical and mechanical terms associated with lens surfaces and their interaction with ocular tissue.

Tribology

Tribology, a domain of mechanical engineering, is the science of friction, lubrication and wear (not as in contact lens wear, but deterioration). It is the study of interacting surfaces in relative motion. Subbaraman and Jones\textsuperscript{9} have described how friction and lubricity can be measured.

Friction

Friction can be defined as the “resistance developed between contacting surfaces when one of the bodies moves, or tends to move, over the other”\textsuperscript{10}. The Coefficient of Friction (COF) is a scaled value which describes the ratio of the force of friction between two surfaces and the force pressing them together. The value depends in part on the materials.
Two useful examples are: ice on steel, which would have a low COF, while rubber on asphalt would have a high coefficient of friction. There are several types of friction / lubrication in the context of contact lens wear. Hydrodynamic lubrication is where a fluid film completely separates two solid surfaces. Boundary lubrication occurs when the two surfaces come into direct contact. Two contrasting contact lens examples are the lid traversing a soaked hydrogel lens on the eye at high speed (hydrodynamic lubrication) which would have a relatively low COF but if the tear film is completely dehydrated or the movement speeds are low the COF would be considerably higher (boundary lubrication).

**Lubricity**

Lubricity can be thought of as the reciprocal of friction. That is when friction is low, lubricity is high. A hydrogel contact lens surface in its dehydrated state is not particularly lubricious, however, introducing a fluid even with very low viscosity or soaking the lens in solution will improve the lubricity and reduce friction when the eyelid slides across the lens surface. The ability of the surface to retain moisture will affect the lubricity.

**Wettability**

This is a more commonly used term in the contact lens world and is used to characterize the adherence of fluid to the lens surface. Wettability can be an in-vitro (or ex-vivo) measure of the contact angle (CA) or a clinical in-vivo assessment of pre-lens tear break up time (TBUT) measurement. Although these are frequently quoted values, there are other key factors that may correlate better with comfort of contact lenses. Maldonado-Codina and Efron suggested that the in-vivo interaction of tears and the lens surface cannot be predicted by CA measurements. Hysteresis (difference between the advancing and receding contact angles) seems to be a better way of expressing the laboratory wettability of lenses and Tighe has shown that hysteresis values of uncoated silicone hydrogels launched in recent years have decreased significantly, in part due to the markedly greater water content.

**Clinical Consequences of High Coefficient of Friction**

It is fair to say that the advancements made in contact lens science and technology have eliminated or minimised many of the complications that pre-dated disposable lenses. Most of those complications were associated with deposition of denatured protein and other lens contaminants, giving rise to auto-immune reactions, mechanical irritation of the tarsal conjunctiva and other ocular tissue, and in some cases, considerable discomfort. Loss of lubricity and increased friction as a result of lens surface contamination were likely responsible for these adverse ocular surface reactions. As lens technology continues to advance it is important to measure the friction not only of fresh lenses but to determine how lens friction changes in response to wearing time and surface deposits.

One of the more dramatic ocular complications that typifies the above description is giant papillary conjunctivitis (GPC) or what is now termed contact lens papillary conjunctivitis (CLPC). GPC was first reported by Thomas Spring in 1974 as an inflammatory reaction of the palpebral conjunctiva more often observed on the upper lid. Large (or “Giant”) papillae, palpebral hyperaemia and mucus secretion are characteristic of the condition. Symptoms include itching, ocular discomfort and poor, variable vision which frequently led to discontinuation of wear. It was not uncommon to observe an apparently dehydrated contaminated lens move 4 or 5 mm with a normal blink, obviously due to the loss of lubricity between the lens and palpebral surfaces. With current lenses and good habits of frequent replacement these findings are quite rarely encountered.

Through the development phase of silicone hydrogel lenses, CLPC has been reported to occur more frequently (especially with continuous wear) than with conventional hydrogel lenses and less with newer silicone hydrogels than first generation. In addition to the design and modulus changes, one would have to suspect that increased water content and methods to retain surface moisture has helped to decrease the incidence of CLPC.

Coincident with the development of silicone hydrogel lenses, new clinical conditions have been reported. In 2002, Korb and colleagues described a condition called lid-wiper epitheliopathy (LWE) which is a band of affected tissue of the marginal conjunctiva of the upper eyelid that wipes the ocular surface. The condition is diagnosed by staining with fluorescein, rose bengal or lissamine green. They found that contact lens wearers who were symptomatic of dryness had a significantly higher percentage of lid-wiper staining compared to asymptomatic wearers.

Pult and colleagues described a condition called lid-parallel conjunctival folds (LIPCOF) which are sub-clinical folds of the bulbar conjunctiva above and parallel to the lower lid margin. It appears that this condition is also more prevalent in symptomatic contact lens wearers but can also be detected in patients with dry eye who do not wear contact lenses.
The suspected etiology of both LWE and LIP-COF is mechanical and in the case of LWE, the tarsal conjunctiva is subjected to increased frictional force or reduced lubricity of the contact lens surface causing micro trauma to epithelial cells. This could be aggravated by a lack of lubrication from tears. The factor these more subtle contact lens related conditions appear to have in common with GPC appears to be reduced lubricity, which probably provokes the symptoms of discomfort and dryness.

**Efforts to Increase Lubricity**

A number of attempts to increase the wettability of the lens or to retain its moisture during the wearing period appear to have been somewhat successful. Examples of incorporating wetting agents into lens materials are polyvinyl alcohol (PVA), polyvinylpyrrolidone (PVP) and hyaluronic acid. These substances have also been used in artificial tears and contact lens rewetting drops. PVP acts as a hydrophilic layer thereby shielding the hydrophobic properties of silicone hydrogel lenses. Other humectants (substances that help to retain water) such as hydroxypropyl methylcellulose (HPMC) and polyethylene glycol (PEG) have been shown to improve wettability of silicone hydrogel lenses. Keir and Jones have eloquently and more extensively described this topic. However it is unknown whether these wetting agents have had a lasting effect on lubricity.

The most recent development in daily disposable silicone hydrogel technology is termed a water gradient lens*, ranging from 33% water content in the core to approximately 80% at the surface. Gel layers that are minimally crosslinked (5-6 μm thick) are graded on the surfaces of silicone hydrogel contact lenses. Sawyer concluded that these gel layers provide a lubricious surface with very low friction coefficients (below μ = 0.01).

Finally, the most compelling evidence of a measurable lens variable that correlates with end-of-day comfort is the coefficient of friction, demonstrated by Brennan and Coles in two separate studies. The efforts of measuring and modifying lens surfaces that truly retain moisture and lubricity throughout the day could be the most important development since the Wichterle soft lens, perhaps even surpassing the discovery of the silicone hydrogel material. 

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Measuring Friction and Lubricity of Soft Contact Lenses: A Review

Comfort may be tied to friction and lubricity.

By Lakshman N Subbaraman, PhD, BSOptom, MSc, FAAO, & Lyndon W Jones, PhD, FCOptom, FAAO

Over the last 35 years, the number of contact lens wearers worldwide has increased from 10 million to 140 million, with the vast majority (over 90%) being fitted with soft lenses. Recent reports suggest that the contact lens industry is healthy and the worldwide annual soft contact lens market is estimated at $5.3 billion, with the U.S. market estimated at $1.9 billion. However, despite this apparently buoyant position, many wearers continue to be dissatisfied with their lenses and approximately 35% of lens wearers discontinue wear, with the majority reporting the major reasons being discomfort and dryness, particularly at the end of the day. Contact lens-related discomfort and dryness is influenced by several factors, and likely include both the interaction of the posterior surface of the lens with the corneal surface and the anterior surface of the contact lens with the posterior surface of the eyelid during the blink.

Hydrogel lenses rapidly attract various components from the tear film, particularly proteins and lipids, following their insertion. These can result in alterations to the surface of the contact lens that can change the frictional forces that exist during blinking. Furthermore, dehydration of lenses can result in increased lid-lens interaction due to a reduction in lens front-surface wettability and lubricity, and the development of corneal epithelial staining due to pervaporation and subsequent desiccation. Studies have suggested that the frictional properties of contact lenses may also be associated with certain clinically observable phenomena, notably lid wiper epitheliopathy and lid parallel conjunctival folds. Finally, increased friction may lead to contact lens associated papillary conjunctivitis due to the mechanical interaction of the palpebral conjunctiva with the contact lens surface.

Issues such as these have made it clear that the frictional properties of lenses are an important design consideration in the fabrication and manufacture of soft lenses. Furthermore, understanding the frictional forces that occur at the lens surface will provide insight into the relationship between the lens material surface properties and...
Alcon offers the DAILIES® family of daily disposable contact lenses and the AIR OPTIX® family of monthly replacement lenses. Multiple studies have shown that daily disposable and monthly replacement contact lens wearers are more compliant* than those who wear 2-week lenses.2,3,4 Compliant patients also return for more eye examinations.1 Read more about this latest study, and see how Alcon can boost your practice, at myalcon.com/power-of-one

*Compliance with Manufacturer-Recommended Replacement Frequency (MRRF).


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biological responses such as protein deposition and bacterial adhesion. However, to-date, very few studies report on the frictional characteristics of soft lenses and contact lens practitioners may be unaware of the relevance of this factor to everyday practice. The scope of this review article is to provide an overview of various methods that have been employed to determine the friction of hydrogel lenses.

**Terminology**

Material scientists and researchers who work on the surface properties of lens materials commonly use terms such as “tribology”, “friction” and “lubricity.” However, eye care practitioners may not be familiar with these terms as they do not use them on a day-to-day basis and a description of these terms is valuable.

Tribology comes from the Greek word “tribos,” which means “to rub.” Tribology is generally defined as the study of three areas — friction, lubrication and wear. These three areas are highly inter-related; however, the relationship between friction and wear is not well understood. Generally, friction is produced when two sliding surfaces come into contact, resulting in wear. Wear can be prevented by lubrication, and the separation of the surfaces by a lubricant will result in a reduction in friction. The purpose of tribological research is to minimize friction and wear, therefore, tribology plays a major role in the effective treatment of some of the common medical conditions involving bodily implants and joint diseases.

Biotribology is a relatively new term introduced in the early 1970s to describe a group of sciences that focus on one single topic — the study of friction, wear and lubrication within biology.

Friction can be defined as the force that acts at the surface of two solid surfaces to resist sliding over one another. The force that prevents one surface sliding over the other is quantified by a simple index called the coefficient of friction (CoF). In order to determine CoF, two measurements are needed: (a) the force required to initiate and/or sustain sliding and (b) the normal force holding the two surfaces together. CoF can then be calculated by dividing the initiating/sustaining force by the normal force. A lubricant can be used to reduce friction between two surfaces. Since a lubricant reduces friction, CoF is an easy measure of quantifying the lubricating ability of any system. Generally, a comparison between CoF generated by an instrument under identical conditions is acceptable. However, comparing CoF values from different instruments under different conditions should be interpreted with caution.

Lubrication is defined as any means capable of controlling friction and wear of interactive surfaces in relative motion. There are two types of lubrication; one where there is a solid-to-solid contact of the sliding surfaces is known as “boundary lubrication” and the other where there is a thin layer of fluid that is present in the intervening space (hydrostatic lubrication) or the motion produces a layer of fluid on which the moving surface planes over the counter face (hydrodynamic lubrication).

**Methods of Measuring Friction and Lubricity**

The most common method for determining the CoF of soft contact lenses is through the use of a microtribometer. Some researchers have used a method based on atomic force microscopy and others have developed novel proprietary techniques to determine the lubricity of contact lenses and the following section describes these various methods.

**Microtribometer**

A microtribometer is an instrument that directly measures the frictional force and the normal force in order to calculate the coefficient of friction. Many different parameters must be controlled to generate repeatable measurements and the following section provides an outline of the parameters that influence the CoF values obtained using a microtribometer.

**Sliding speed:** Test speeds have a large effect on the measured COF and speeds as low as 0.01 mm/sec have been used to measure “boundary lubrication”, which occurs when the lens is in direct contact with
the ocular tissues. Higher speeds approximating the blink speed of 12 cm/sec have been used to measure “mixed” or “hydrodynamic lubrication”, where a thin fluid film separates the contact lens from the ocular tissues. Studies have used a wide range of sliding speeds (63 to 6280 µm/sec, 0.01 to 0.5 cm/sec, or 10 to 600 µm/sec) to determine the effect of sliding speeds on the reported CoF values.

Normal Force Pressure: In-vivo eyelid pressures are typically estimated at 1-7 kPa and achieving accurate force measurements at these low pressures can be challenging. A recent study has determined frictional values at very low contact pressures, approaching 1 kPa.

Substrate / Counter Surface: All friction measurements involve two surfaces and the choice of substrate against which to determine the CoF can affect the reported results. Substrates utilized include glass, stainless steel, or mucin-coated silanized glass.

Lubricating fluid: Nairn and colleagues used various commercial ophthalmic solutions including B+L ReNu, Allergan Complete, Alcon Opti-Free and B+L saline and showed that differing lubricants resulted in differences in the reported CoF values. Artificial tear fluids and solutions containing a variety of tear proteins that mimic human tears have also been used as lubricating fluids.

Type of movement: Microtribometers typically use either a flat plate or a curved probe that is moved across the lens surface. The flat plate method maintains contact with only a single point on the contact lens surface during testing, while the probe method is able to expose fresh lens surface to the probe as the probe is moved across the lens surface.

Lens sample preparation: To-date, all published CoF data has been conducted only on unworn lenses. The effects of lens wear and contact lens care solutions have not been adequately tested in order to determine whether the coefficient of friction is likely to change with time after exposure to tear film components and further work is warranted in this area.

Finger Lubricity Method
Recently, a qualitative “finger rubbing” method has been described to determine contact lens lubricity. In this method, contact lenses were rinsed overnight in a phosphate buffered saline (PBS) solution to remove any packaging solution, and the investigator rubbed the lens between their thumb and index fingers and the lubricity was rated on a 0 (most lubricious) to 4 (least lubricious) scale. The advantage of this method is that it is a simple, quick method that does not require any sophisticated instrumentation. The authors reported that this method was highly repeatable, but only when used by an experienced investigator. A major disadvantage of this method is that it is a limited qualitative scale and not all lens types can be differentiated with this technique.

Inclined Plane Method (Figure 1)
This is a novel, quantitative method of determining contact lens friction using a PBS solution. In this method, a clean glass plate is adjusted to a desired angle in a PBS bath. The contact lens under test is placed at the top of the glass plate and a 0.8 gram stainless steel ferrule (0.88 kPa) is placed on the lens to initiate movement. A minimum critical angle is
determined, which maintains the movement of the lens over a distance of approximately 100 mm. The tangent of the critical angle is a measure of the kinetic coefficient of friction. Thus, in this method, the tangent of the largest angle where the lens is unable to maintain movement will determine the kinetic coefficient of friction.17

Atomic Force Microscopy (Figure 2)
Atomic force microscopy (AFM) is a standard technique used to study the surface topography of conventional and silicone hydrogel contact lens materials.19 AFM is a very powerful tool for high-resolution examination of the contact lens surface and also permits the analysis of surface topography and roughness by means of a non-destructive methodology. AFM consists of a microscale cantilever with a sharp tip, which scans the surface of the lens. The cantilever is typically made of silicon or silicon nitride with a tip radius of curvature in the order of nanometers. The AFM can be operated in a number of modes, including static (also called contact) mode and a variety of dynamic (non-contact or tapping) modes, where the cantilever is vibrated. The advantage of AFM over traditional microscopic techniques is the high-resolution, three-dimensional images and also that topographic information can be obtained in several conditions (such as aqueous, non-aqueous or dry), thereby eliminating the need for sample preparation.

Kim and colleagues15,16 used a contact-mode AFM to determine the surface properties of pHEMA-based soft contact lenses. AFM images of the lens surface were taken in two conditions: (a) with the lens surface exposed to air (“surface-dehydrated”) and (b) in the presence of saline solution on the lens surface. After successfully optimizing a method to quantify friction using AFM, the authors concluded that the friction force imaging of the “surface-dehydrated” soft contact lenses made of cross-linked pHEMA showed low friction at the surfaces. In saline, the surface friction was significantly reduced compared to those measured for the “surface-dehydrated” lens.15 In a recent study, Rudy and colleagues20 determined the surface mechanical and tribological properties of silicone hydrogels using AFM. In this study, they measured the elastic modulus by indenting a probe into the surface of the hydrogel in a controlled manner and obtained a modulus value by fitting the characteristic force versus indentation behaviour. Their results showed that pHEMA-based etafilcon A lenses have a modulus between 100 and 130 kPa, whereas balafilcon A lenses were an order of magnitude higher in value. The frictional properties followed a similar trend, with plasma surface-treated lenses (such as balafilcon A) exhibiting CoF values five times those of defilcon A water gradient silicone hydrogels. These studies show that the elastic modulus and frictional properties of different hydrogel and silicone hydrogel lenses can be evaluated at a nanoscopic level using AFM.

Conclusions
Determining the frictional properties of soft lenses is complicated and a review of the literature reveals that there are several methods of determining the lubricity of contact lens materials. Due to the vast dif-
In this work, end-of-day comfort data obtained from over 700 separate 1-month wearing trials were derived using a sensitive and sophisticated method. The friction data showed consistently high correlation with comfort, implicating that coefficient of friction could be a major driving factor in subjective comfort. However, data from more carefully conducted clinical trials are needed to determine the relationship between subjective symptoms of discomfort and dryness and the lubricity of various commercial contact lens materials. The influence of contact lens care regimens and how they influence the friction values of contact lenses should also be investigated.

The authors would like to acknowledge Alcon Laboratories Ltd, USA for their support in developing this article through an unrestricted grant.

References

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References:
Introducing Water Gradient Technology

Daily disposable contact lenses with water gradient technology represent a new era in contact lens wear.

By Ralph Stone, PhD

Contact lens materials have evolved from PMMA lenses of the 1950s to oxygen permeable rigid lenses of the 1980s and beyond. The introduction of hydrogel materials in the early 1970s brought new levels of comfort. Disposable lenses in the 1990s evolved further with the introduction of silicone hydrogels. Material and manufacturing technologies have made possible daily disposable lenses, something that would have been unthinkable in the early days of soft lenses.

As materials evolved, it became useful to find a way to group these materials based on fundamental characteristics including water content and the presence of ionic ingredients for hydrophilic materials and by the hydrophobic components for the rigid hydrophobic materials. By 1994, FDA listed 34 different soft contact lens materials and 95 brands and 39 hydrophobic contact lenses. These grouping systems served the industry well through the both the hydrophobic lens and hydrogel lens eras, but with the introduction of silicone hydrogel materials, the system had to be expanded to include these biphasic materials.

A New Era

Since the introduction of silicone hydrogels in 1998, these materials have become the dominant choice of fitting practitioners. Today these materials are considered to be a separate class of hydrophilic contact lens materials and experts from around the world are evaluating if additional groups are needed. The latest introduction, Dailies Total1 (delefilcon A) water gradient daily disposable contact lenses by Alcon Laboratories, represents a landmark in the continuing revolution in contact lens materials that underscores the need for a new grouping system, because this material is truly in a class by itself as the first water gradient silicone hydrogel contact lens.

Dailies Total1 daily disposable contact lenses have a revolutionary structure based on a silicone hydrogel core and a water gradient surface that creates a transition from core water content of 33% to a surface water content in excess of 80% at the interface with the tear film. The surface of the lens, like the corneal epithelium and glycocalyx, has a brush-like structure that binds water in this region of the lens. A water gradient is created...
by cross-linked polymeric wetting agents that form a soft, hydrophilic surface gel, which is embedded into the core, creating a smooth transition from the core to the surface. The water gradient provides the lowest silicone surface content of any silicone hydrogel lens material.

Figure 1 shows a representation of this novel approach. Figure 2 shows an Atomic Force Microscopy (AFM) image of a cross section of the lens demonstrating the change in material properties from the core to the surface. With a center thickness of 90 microns, the water gradient surface represents slightly more than 6% of the central lens thickness on each side.4

The color change in the AFM image represents a change in water content, modulus and chemical composition that is not seen in any other lenses tested. The water gradient provides a lubricous lens surface that is also substantially softer than the core of the lens.6

Beyond Oxygen
With the development of materials and lens care systems over time, we have recognized that we can solve some of the issues of contact lens lenses and lens wear with improved technologies. The understanding of the role of oxygen and transmission through the lens has led to the creation of lenses that do not cause oxygen deficiency at the cornea. It is now recognized that enhanced oxygen maintains corneal function and decreases edema and other changes due to hypoxia. Dailies Total1 lenses have a central Dk/t of 156 at -3.00 diopters. This is the highest of the currently available daily disposable contact lens materials. Table 1 shows a comparison of Dk and central Dk/t of several daily disposable lens materials.

Oxygen has not solved all contact lens wear issues. Despite advances made in lens materials to date, it has been reported that nearly 15% percent of patients will stop wearing contact lenses every year.7 The most common reasons reported for discontinuing wear are discomfort and dryness.8-11

Enhancing Comfort: Modulus, Wettability, Lubricity
Three primary approaches have been suggested to enhance comfortable wear of contact lenses: providing a low modulus hydrogel surface, maintaining wettability throughout the day, and minimizing the friction of the lid crossing the front lens surface.

The water gradient of Dailies Total1 lenses address the modulus challenge by providing a soft, cushioning layer on the outer surface of lens. This can be measured using an AFM modulus scan (Figure 3).5

In addition to the modulus gradient observed in the AFM scan, there is an ultra-soft surface gel on the outermost surface of the lens. The high water content at the surface provides an extremely wettable interface with the tear film. Measurements by Menzies and Jones12 showed Dailies Total1 lenses had lower advancing and receding contact angles, as measured by a sessile drop, than other tested daily disposable contact lenses with the exception of nelfilcon A (Dailies Aqua Comfort Plus contact lenses).

Wettability is only one measure of ways to help
keep contact lenses comfortable. Brennan reported that lubricity as measured by coefficient of friction is highly correlated to comfort (r=0.90, p<0.01). Korb and colleagues reported that there is a correlation (p<0.00001) between lid wiper epitheliopathy and dryness symptoms associated with wear of contact lenses. In studies of 105 symptomatic and asymptomatic lens wearers, Korb and colleagues found 80% of symptomatic patients showed the presence of lid wiper staining compared to 13% of asymptomatic patients within the first 4 hours of wear.

The novel water gradient surface of the Dailies Total1 lenses provides a highly lubricious surface. Contact lenses can provide hydrodynamic lubrication during the fastest part of a blink as the tear film is maintained between a contact lens and the eyelid. At lower ocular movement speeds, however, a contact lens is in direct contact with the ocular tissues resulting in much higher friction. The soft, high water surface of the Dailies Total1 lenses acts as a boundary lubricant during these low speed ocular movements providing excellent lubricity (low coefficient of friction). Measurements by Sawyer and co-workers found that the coefficient of friction of Dailies Total1 lenses was comparable to or even lower than the coefficient of friction of epithelial cells. Additional qualitative and quantitative methods have been used to estimate the lubricity (or its inverse the coefficient of friction) and have demonstrated the highly lubricious nature of the Dailies Total1 lenses. When measuring the lubricity or friction of Dailies Total1 lenses it is important to utilize pressures similar to those found in

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**Table 1**

Comparison of Oxygen Permeability and Transmissibility of Daily Disposable Lens Materials

<table>
<thead>
<tr>
<th>Lens Material</th>
<th>Dk</th>
<th>Dk/t**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deleficon A (Dailies Total1 contact lenses, Alcon)</td>
<td>140*</td>
<td>156</td>
</tr>
<tr>
<td>Narafilcon A (Acuvue TruEye, Johnson &amp; Johnson Vision Care – not available in US)</td>
<td>100</td>
<td>118</td>
</tr>
<tr>
<td>Narafilcon B (US version Acuvue TruEye, Johnson &amp; Johnson Vision Care)</td>
<td>55</td>
<td>65</td>
</tr>
<tr>
<td>Etafilcon A(1-Day Acuvue Moist, Johnson &amp; Johnson Vision Care)</td>
<td>28</td>
<td>33</td>
</tr>
<tr>
<td>Omafilcon A (Proclear 1 Day, CooperVision)</td>
<td>33</td>
<td>36</td>
</tr>
<tr>
<td>Nesofilcon A (Biotrue, Bausch + Lomb)</td>
<td>42***</td>
<td>42</td>
</tr>
</tbody>
</table>

*Alcon data on File 2010
**Dk/t calculated using manufacturer’s published center thickness for -3.00 diopter lenses when available. Others as published in Tyler’s Quarterly
***Data from FDA 510(k) K113703 Summary June 6, 2012

**Table 2**

Comparison of Ocular Physiology* and Surface Appearance of Two Silicone Hydrogel Daily Disposable Lenses and Dailies Total1 Daily Disposable Lenses with a Water Gradient Surface.

<table>
<thead>
<tr>
<th></th>
<th>Dailies Total1 Contact lenses (deleficon A)</th>
<th>Clariti 1-Day Contact lens (7ettab II 3)</th>
<th>p value compared to Dailies Total1 lenses</th>
<th>Acuvue TruEye Contact lenses (narafilcon A)</th>
<th>p value compared to Dailies Total1 lenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corneal Staining (0-10,000)</td>
<td>25+54</td>
<td>38+ 70</td>
<td>p&lt;0.01</td>
<td>74+ 117</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>Conjunctival Staining (0-100)</td>
<td>4+ 5</td>
<td>30+ 12</td>
<td>p&lt;0.01</td>
<td>10+ 8</td>
<td>No difference</td>
</tr>
<tr>
<td>PL-NIBUT (seconds)</td>
<td>5.7</td>
<td>4.7</td>
<td>p&lt;0.01</td>
<td>4.7</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>Graded wettability compared to Dailies Total1 lenses</td>
<td>.27</td>
<td>p&lt;0.01</td>
<td>.34</td>
<td>p&lt;0.01</td>
<td></td>
</tr>
<tr>
<td>Difference in observed deposition compared to Dailies Total1 lenses</td>
<td>.31</td>
<td>p&lt;0.01</td>
<td>.13</td>
<td>p&lt;0.01</td>
<td></td>
</tr>
</tbody>
</table>

*Mean plus/minus standard deviation
lenses and two competitive silicone hydrogel daily disposable lenses. While the other daily disposable lenses tested were acceptable, Dailies Total1 lenses showed the least impact on ocular physiology and the least change in lens surface appearance when evaluated after 8 hours of wear. The results are shown in Table 2.

In a separate report by Varikooty and colleagues, the subjective comfort of 53 enrolled symptomatic patients from this study was evaluated. The comfort was measured at 4, 8 and 12 hours. At each time point Dailies Total1 lenses was numerically superior to other silicone hydrogel daily disposable contact lenses.

Conclusion

Dailies Total1 lenses provide a new concept in contact lenses combining the benefit of a high permeability oxygen silicone hydrogel core and a water gradient transition from the low water silicone hydrogel core to a high water content surface. This new technology is made possible by the next generation of Alcon’s patented LightStream Lens Technology. The high water surface provides a low modulus, highly wettable and lubricious surface. This revolutionary technology does not fit the current classification approaches for either the conventional hydrophilic lens materials or the biphase silicone hydrogels, and stand alone as a novel approach to contact lens chemistry.

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The Development of Dailies Total1 Water Gradient Contact Lenses

Research led to a departure from using a single bulk material for the whole lens.

By John Pruitt, PhD and Erich Bauman, OD, FAAO

The development of the delefilcon A lens material that makes up Dailies Total1 contact lenses began more than 10 years ago and involved a dedicated multi-national team of scientists, engineers and clinicians. Early in the development, the team had many intense discussions about what lens properties should be targeted in order to create the most comfortable contact lens possible. The team quickly recognized the many limitations and trade-offs inherent in relying on a single bulk material.

The R&D team recognized that an extremely low modulus may make a lens easier to fit and help provide improved comfort but at the cost of decreased lens handling performance. There also seemed to be a limit to materials that a low water content material with high levels of silicone would provide excellent oxygen transmissibility, good handling characteristics and resistance to dehydration. Conversely, from our experience with (non-silicone) traditional hydrogel materials, we knew that extremely high water content materials without silicone could provide excellent wettability, lubricity, and resistance to lipid fouling.

The surface coefficient of friction, or lubricity, has been shown to have a high correlation with lens comfort scores.

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Dr. Bauman is project head for Dailies Total1 projects within Vision Care Research & Development at Alcon Laboratories, Inc. He received his doctor of optometry degree with honors from the Southern California College of Optometry in 1982 and an MBA from Coles College of Business in 2001.
how soft one can make a lens material. The modulus of corneal epithelial cells is less than 0.02 MPa and it seemed impossible to make a contact lens material as soft as that without it simply falling apart.

Following the paradigm of using multiple materials as in the cornea, we realized that some of these properties, such as oxygen transmissibility and lens handling, could be controlled by a lens ‘core’ material while other properties like wettability and lubricity were only important at the surface. A lens with only a single water content, modulus or chemistry would always entail some level of compromise. The team arrived at the question: “why should patients have to settle for the same water content at the core and surface, or indeed the same material chemistry at the core and surface of a lens?” This led to a radical departure from single bulk material thinking and formed the basis for the development of the delefilcon A water gradient lens material.

**Revolutionary Change**

A measurable change can be demonstrated in the lens material, the water content and the modulus of delefilcon A from core to surface. This represents the first-ever water gradient contact lens designed to feature an increase from 33% to more than 80% water content from core to surface. To enable this water gradient, the delefilcon A lens material transitions from a highly breathable silicone hydrogel material at the core to a non-silicone hydrophilic polymer structure at the surface (Figure 1). This enables a lens with a Dk/t of 156 (at the center of a -3.00D lens) combined with a surface-water content of over 80% as seen in Figure 2. A gradient occurs between the two areas in which the water content rapidly increases and the material shifts from a silicone-rich core material to an essentially silicone-free surface gel. This surface material forms an ultrasoft surface gel and makes up about 10% of the lens thickness. While the average water content of the ultrasoft surface gel exceeds 80%, the water gradient structure allows the water content to approach almost 100% at the outermost surface of the lens.

Several laboratory techniques have measured this change in lens material properties including Atomic Force Microscopy (AFM), Neutron Reflectometry, and Fluorescent Laser Confocal Microscopy. These
methods demonstrate the gradient in modulus and other lens properties across the lens cross section, not seen in other lens materials.

The modulus of the lenses also changes with the material becoming much softer at the surface of the lens with the outer surface having a compression modulus of only about 0.025 MPa. The modulus of the lens core is maintained at 0.7 MPa for excellent insertion handling. The surface modulus of delefilcon A is almost as soft as the corneal epithelial cells yet this ultra soft surface gel is able to maintain its integrity because it is supported by the lens core material. In a similar manner the ultra soft corneal epithelial cells are supported by collagen fibrils, giving the cornea an overall bulk modulus that is much higher than the modulus of the individual cells.

**Highly Breathable Daily Disposable Lens**

Why do we need such a high Dk/t for a daily disposable contact lens? There are several factors to consider. Stated Dk/t values (and even theoretical flux or equivalent oxygen estimations) are normally provided only for the center of a -3.00D lens. The greater peripheral lens thickness means oxygen transmissibility is lower with minus powers, but in plus powers, the central oxygen transmission values will be lower than the stated value for -3.00D. Figure 3 illustrates this with the color oxygen maps across the whole lens in different materials and powers. The blue end of the spectrum is used to indicate high Dk/t and red shows areas of lower Dk/t. It has become apparent that a single Dk/t value isn’t sufficient to completely characterize the oxygen transmission in contact lenses. Furthermore, the published Dk/t values for the lenses only represent a small portion at the center of a -3.00D lens. The peripheral oxygen transmissibility is generally much lower as seen in the colored maps. Research demonstrates that peripheral oxygen transmission is equally important to ocular health as that in the center. In addition, different patients have different oxygen demands, some of which may not be predictable during a routine examination, even when using a slit lamp. Thus, starting with the highest available central Dk/t value is in the best way to avoid hypoxic concerns and meet the needs of various patient lifestyles.

Oxygen transmissibility in delefilcon is largely determined by the core of the lens because it comprises the
majority of the lens thickness. Of particular interest are the unique properties at the surface of the lens, because these are key to a comfortable lens-wearing experience.

The Importance of Surface Lubricity

The comfort of a contact lens may be influenced by many factors ranging from the modulus of the material, lens thickness, and water content to lens design and parameters. The surface coefficient of friction, or lubricity, has been shown to have a high correlation with lens comfort scores. Lubricity is the inverse of friction and, for a contact lens, is described as how easily the components of the ocular surface, such as the palpebral conjunctiva, can slide across the lens surface. We blink about 14000 times per day. With each blink, the superior lid has to slide down, then back up over the lens surface. As such, it makes sense that lubricity is highly predictive of lens comfort. Lubricity can be detected with the fingers as a slippery feeling and it can be measured by using either an inclined plane or a micro tribometer. Regardless of the method used to measure lubricity, it is important that the pressures reflect those found in the ocular environment — in other words, matching those exerted by the eyelid against the lens on eye). This is especially important when measuring the lubricity of delefilcon A because the extremely soft water gradient surface structures can be artificially crushed if measured at pressures that exceed those found in the eye thereby giving erroneous lubricity results at high testing pressures.

Using kinetic coefficient of friction, measured by the inclined plate method, delefilcon A has been shown to have extremely low friction (excellent lubricity).

A new contact lens with different core and surface properties meant that detailed research was needed to optimize the chosen design parameters. Numerous studies were conducted to co-optimize the base curve, diameter and lens design. Ultimately, the combination of an 8.5mm base curve with a 14.1mm diameter was selected to give optimal centration and lens movement. The full technical specifications and
range of parameters can be seen in Table 1.

**Exceptional Comfort Throughout the Day**
The outcome of this superior lubricity is outstanding wearer comfort through the end of the day. In a clinical study with 104 subjects, cumulative comfort scores were superior for Dailies Total1 contact lenses in comparison with other silicone hydrogel daily disposable lenses. In a group of 53 symptomatic subjects, 100% of them could wear Dailies Total1 contact lenses for at least 8 hours and 85% were able to wear them up to 12 hours. In comparison to their habitual lenses, the majority of the subjects were able to wear Dailies Total1 contact lenses for clinically significant longer periods of time.

**The Start of a New Era**
Since soft contact lenses were first introduced, there have been numerous incremental changes to materials to improve water retention and wearer comfort. Ciba Vision introduced the first silicone hydrogel contact lens in 1998, ushering in a new era in lens material technology that has triggered extensive steps to improve oxygen transmission for patients worldwide. The creation of the first water gradient contact lens, featuring an increase from 33% to over 80% water content from core to surface, marks the start of yet another new era in contact lenses, and with it, hope for a new era in comfort for contact lens wearers around the world. CLS

*Editor’s note: A similar article appeared in the April 5, 2013 edition of Optician.*

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

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**Table 1**

<table>
<thead>
<tr>
<th>Material</th>
<th>Delefilcon A</th>
</tr>
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<tbody>
<tr>
<td>Surface Water Content (%)</td>
<td>&gt;80%</td>
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<tr>
<td>Base Curve (mm)</td>
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<tr>
<td>Center Thickness (mm -3.00D)</td>
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<td>Core Water Content (%)</td>
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<td>Core Modulus (MPa)</td>
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<tr>
<td>Diameter (mm)</td>
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<td>Handling Tint</td>
<td>VISITINT lens</td>
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<tr>
<td>Manufacturing</td>
<td>Newest generation of LightStream Technology enables the creation of the water gradient. Lenses contain phosphatidylcholine, an ingredient also found in natural tears.</td>
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<table>
<thead>
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<th>Power Ranges (at launch)</th>
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<tr>
<td>Diopters</td>
<td>-0.50 to -6.00 (in 0.25 steps)</td>
</tr>
<tr>
<td></td>
<td>-6.50 to -10.00 (in 0.50 steps)</td>
</tr>
</tbody>
</table>

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**References**

Some Surfaces Are Worth Protecting

The Ocular Surface is One.

The SYSTANE® portfolio includes products that are engineered to protect, preserve and promote a healthy ocular surface1-5. See eye care through a new lens with our innovative portfolio of products.

References

Groundbreaking Technology Debuts in Daily Disposable Market

Panelists discuss a unique new lens that has surprising characteristics designed to defeat discomfort.

Dr. Eiden: Today, we’ll share our experiences with what we believe is a revolutionary new contact lens technology. The Alcon Dailies Total1 lens was designed to address some of the key challenges we still face in daily practice in a way that we haven’t been able to do before, relating to all-day comfort, visual performance and breathability. Let’s begin by discussing some of those challenges.

Number One Complaint

Dr. Eiden: Dr. Brujic, do you always know when patients are dissatisfied with their habitual contact lenses?

Dr. Brujic: I see two types of challenging patients. The first is the non-complaining patient, and the second is the habitually complaining patient. The non-complainers seem to have no problems, but often, I think they’re reluctant to complain, because they’re concerned they’ll have to stop wearing contact lenses.

Dr. Eiden: How do you help these patients open up?

Dr. Brujic: I ask them to rank the quality of their vision and the comfort of their lenses, each on a scale from 0 to 10. Many people who tell me their comfort is “fine” or “great” give their lenses a grade that is less than the 10 I’d expect for comfort that is “fine.” This is a huge opportunity for me to introduce new technologies to these patients, as well as to patients who do verbalize their complaints.

Dr. Eiden: Dr. Jasper, do you find the same thing happening in your practice? Do you see it as an opportunity to make changes for your patients?

Dr. Jasper: Absolutely. The most common complaint I hear is that patients can’t wear their lenses as long as they want to during the day. When a patient tells me this, it’s my job to find out why. Typically, it’s because the lenses are not comfortable, or the patient’s lenses feel dry. Another challenge is the patients who tell us what they think we want to hear just to make us happy.

Dr. Eiden: What do you do when you suspect a patient is just telling you what you want to hear?

Dr. Jasper: I help them get past that by rewording my questions. I may ask, “What’s the longest amount of time you can wear your lenses comfortably during the day?” or “How often do you switch to your eyeglasses before the end of the day?”
Dr. Eiden: Dr. Nichols, what questions do you ask your patients to uncover any comfort issues?

Dr. Nichols: I always ask patients how many hours a day they wear their lenses, how many hours they want to wear them and what things they’ve tried to eliminate some of their discomfort. In my practice, I see patients who are having more significant issues. Many of these patients are former contact lens wearers who really want to wear them again. I think sometimes we’re quick to say, “You’re done with contact lenses,” instead of trying something new. When patients start to drop out in their 30s or 40s, we need to try to figure out if we can do something to keep them comfortable in lenses, because they want to wear them.

Dr. Eiden: Other issues that concern us in terms of contact lens performance include ocular health response and visual response. Dr. Schachet, how important are these aspects in comparison to comfort issues?

Dr. Schachet: They’re all important and inter-related. Most of my patients who have discomfort have either a dryness problem, which can be accompanied by fluctuating vision, or they’re not using the ideal lens care solution for their lenses. So, whether we’re talking about initial comfort or end-of-day comfort, I look at those two things primarily before looking at anything else. We have to be proactive, and we need to listen. When we listen carefully to what patients say, the problem often becomes apparent even before we go to our instrumentation.

Unmet Needs in Daily Disposables

Dr. Eiden: Dr. Kassalow, you fit a significant number of daily disposable lenses. What impact has this modality had on your practice?

Dr. Kassalow: The four areas I always focus on when discussing contact lenses with patients are comfort, convenience, vision and health. Daily disposable lenses hit each of those areas square on. From my experience, daily disposable lenses are the most comfortable modality, and patients who wear them are my happiest group of patients. When I see a patient who’s wearing daily disposable lenses, I know that 9 out of 10 times, it will be a relatively easy office visit.

Dr. Eiden: How do they rate their vision?

Dr. Kassalow: They’re just as happy with their vision, because every day, they have a fresh lens. The lens is wet and clean, and they like that. They also love the convenience. They don’t have to use care solutions and feel like a chemist every night.

Dr. Eiden: And health?

Dr. Kassalow: My patients and I both love the
fact that daily disposable lenses are a healthy option. The modality has been a fantastic practice-builder. Overall, my patients are happier than they were before they started wearing daily disposables.

**Dr. Eiden:** Where do you see opportunity for advancement in daily disposable lenses?

**Dr. Kassalow:** Despite having many daily disposable lenses, we still have a group of patients who aren’t comfortable wearing them, so I’m excited about the Dailies Total1 lens and the advent of this new technology. I think it will fundamentally shift the comfort curve.

**Dr. Jasper:** I think it all comes back to the one thing we’ve discussed so far. Discomfort is still an issue for some patients. I still have patients who tell me they can wear their lenses for only 6 hours a day.

## New and Unique Properties

**Dr. Eiden:** Dailies Total1 technology is truly revolutionary, because it’s totally different from any other material. It’s the first water gradient silicone hydrogel lens. Dr. Brujic, what is meant by water gradient and how is this lens different from any other HEMA or silicone hydrogel lens?

**Dr. Brujic:** Dailies Total1 lenses are manufactured in a new silicone hydrogel material called dele-filcon A, which is designed to enable a gradual transition from 33 percent water at the core of the lens to over 80 percent at its surface. Amazingly, this happens in a 6-micron space.

**Dr. Nichols:** All contact lenses aim to simulate the ocular surface and conform to the environment of the tears in a way that enhances the tears or at least doesn’t harm anything about the tears — almost as though the lens isn’t there. In short, the Nirvana of contact lens wear is to have no lens awareness. A number of studies have shown that changes to the ocular surface tissues are highly associated with symptomatic contact lens patients.1,2 This lens has a surface that mimics the natural hydrophilic ocular surface.

**Dr. Eiden:** Dr. Kassalow, how do you explain the concept of lubricity to your patients?

**Dr. Kassalow:** I always talk about lubricity as a feature of the lens. Different patients have appetites for different amounts of information, so to some patients, I say, “This is the single best, most comfortable lens I’ve worked with in my 25-year career. Let’s try it,” and they say, “Great. Let’s do it.” Others may tell me they’re comfortable with their current lenses and ask for more information. For them, I focus on how lubricity equates to comfort.

**Dr. Schachet:** What’s nice about this lens is that the lid has no effect on it because it virtually glides over water. That’s another point that makes it easier for patients to understand.

**Dr. Eiden:** Handling a contact lens can be a challenge for some patients. We always talk about the convenience of daily disposables, but I’ve had patients reject them simply because they were difficult to handle. Dr. Jasper, tell us about the modulus gradient and how that influences lens handling.

**Dr. Jasper:** Dailies Total1 lenses have a low-modulus surface, which enhances comfort, and a high modulus core, which facilitates ease of handling. I proactively explain to patients how I want them to apply and remove these lenses. I think the most noteworthy characteristic, especially for patients who have worn lenses all their lives, is that after applying the lens, they hardly know it’s there — except that they can see. Lens removal may be somewhat challenging for some patients. I instruct them to be sure their hands are thoroughly dry before they remove the lenses.

**Dr. Eiden:** The same attribute that makes the lens so lubricious makes it somewhat difficult to remove if your fingers are wet, because it just slides right over the lens surface.

**Dr. Brujic:** I refit a patient who’d been wearing another brand of daily disposable lenses into Dailies Total1 lenses. When he tried to remove them by pinching them off of his cornea, he had some trouble. After I explained how to remove these lenses — the slide-and-pinch technique — and that he was having trouble because of how slick the lens surface is, he suddenly said, “Wow, now I really understand why this is such a comfortable lens.”

## Highest Dk/t in a Daily Disposable

**Dr. Eiden:** With a Dk/t of 156 (@–3.00D), Dailies Total1 lenses have the highest oxygen transmissibility of any daily disposable lens. Assuming perfect compliance, do you think the cornea needs this much oxygen?

**Dr. Schachet:** Each patient’s requirement for oxygen is different, but I don’t think there’s anything wrong with aiming for high oxygen transmissibility.

**Dr. Jasper:** We don’t know every reason why people drop out of contact lenses. People say discomfort and dryness, but it seems to me if you provide them with the most oxygen throughout a lifetime of contact lens wear, they’ll have fewer problems. As Dr. Schachet mentioned, we don’t know what each individual’s unique oxygen need is. It depends on their lens, where they live, what they do, and so on, so going high in my mind is not a bad thing.
Dr. Brujic: It used to be a more relevant argument when we were trying to decide between oxygen transmissibility and wettability. With the Dailies Total1 lens technology, we don’t have to give up either.

Dr. Jasper: I tell my patients, “I want to give you a contact lens that is like having nothing on your eye.” In other words, we want a lens that’s the least like a lens, and I would hope that every company that works with contact lenses would strive to do that for our patients.

Dr. Eiden: That is a powerful statement. Why do we put a contact lens on anybody’s eye? To help them see better. So, the more that it’s like nothing, other than vision correction, the better it is for our patients.

Personal Experiences

Dr. Eiden: We’ve discussed many of the attributes that make Dailies Total1 unique and exciting. Most of us have had the opportunity to wear these lenses. I’d like to get your personal feedback on wearing these lenses.

Dr. Nichols: I’m the perfect example of a patient looking for a more comfortable daily disposable lens. I’m probably always going to have some comfort issues, because I work long hours late at night on the computer. I’ve worn Dailies Total1 lenses for about 6 months, and I can wear these lenses longer and more comfortably than any other daily disposable lens that I’ve worn.

Dr. Schachet: Overwhelmingly, this is the most comfortable lens I’ve ever had on my eye, and that is directly attributable to the water gradient. When it’s on the eye, you don’t even know you’re wearing a contact lens. It’s the most incredible lens-wearing experience I’ve had in all the years I’ve been practicing.

Dr. Nichols: Our patients deserve the chance to try these lenses. I don’t think people recognize they’re uncomfortable until they experience comfort.

Dr. Eiden: More than a year ago, I had my first exposure to this technology in Europe. At the end of my first day wearing the lens — we sat down to dinner at about 11:00 p.m. — I realized I still had the lenses on, but I didn’t feel them. That’s never happened to me before. Usually after 3 or 4 hours, I have to peel the lenses off of my eyes.

We’ve recounted our personal experiences. Now, let’s discuss how our patients are reacting to Dailies Total1 lenses.

Patients’ Experiences

Dr. Brujic: One of the high moments for me as a clinician is putting lenses on eyes at the beginning of lens wear, because that sets a precedent in a patient’s mind of how that lens will perform. The beautiful thing about the Dailies Total1 lens is its excellent initial comfort.

Dr. Eiden: Dr. Jasper, you had an anecdote you wanted to share.

Dr. Jasper: One of my patients, a teenager, was wearing another lens, apparently successfully, but I wanted her to try the Dailies Total1 lenses. As soon as she put them on her eyes, she said, “Oh my goodness. I had no idea my contacts were supposed to feel like this.” She didn’t really understand how to answer my questions about comfort, but once she experienced the “no-lens” feeling, she understood what it was really supposed to be like.

Dr. Kassalow: When a patient comes in happy and with the attitude “if it ain’t broke, don’t fix it,” it’s easy for us to buy into that, because it makes our day go more smoothly. When contemplating a change for one of these patients, I sometimes ask myself, “Am I setting myself up for headaches? Am I slowing down my day? Am I inconveniencing the patient?” Sometimes, my inclination is to just leave well enough alone. Every person on whom I’ve tried the Dailies Total1 lens has had a positive experience. It doesn’t create that backlash of having to try a different lens and repeat the cycle. That’s an important dynamic in my practice that will prompt me to reach for this lens frequently. It’s not creating more work for me. It’s making my day go faster, and I’m putting patients into a premium product.

Dr. Nichols: I like the idea that it streamlines your process, because you’re not trying a lens that might be uncomfortable. You’re confident this lens will be successful.

Dr. Eiden: We have to constantly present new technologies and reinvent ourselves to give patients a reason to come to see us regularly. For that reason, I’ve presented these lenses to happy patients who apparently have no problems. I say, “Yes, I know everything is great, and if you want to continue with your current lenses, you can, but I want you to test-drive some new technology.” I’ve found that these patients do see an improvement. It may not be as dramatic as the improvement seen by symptomatic patients, but they still see a bump up.

Dr. Brujic: That’s the true test of good technology: taking an asymptomatic patient, someone who has no problems, and improving his experience. This lens is giving us the ability to do just that.

Dr. Kassalow: I’ve definitely seen that happen. Several hundred of our patients are wearing a com-
petitor’s product that is being discontinued. We mailed them information, letting them know the product would no longer be available, and we invited them to come in and try the Dailies Total1 lens. Four out of five of the people who have tried this lens so far have said, “Wow, thanks, doc. This is better than I knew I could have.”

Dr. Schachet: Another patient whom we haven’t discussed is the new contact lens wearer. Anyone who’s never worn a contact lens has an opinion of how it will feel on their eyes. When new wearers try Dailies Total1 lenses, they’re amazed, because they don’t even know it’s there.

Dr. Nichols: That’s a good point. Why not start with innovative technology rather than “fix” a problem? Many patients are accustomed to new technology in other aspects of their lives.

Dr. Eiden: That’s an interesting perspective. We’re “fixing” so many of our patients because they have contact lens-associated problems. This technology takes us to a whole new level in terms of prevention — having patients start with a great lens so they can stay with it for a long time.

Dr. Schachet: Even though this is the closest to a perfect lens we have, we have to remember that some patients will have dryness issues. If we don’t address that, they won’t be able to wear the lenses all day.

Dr. Kassalow: That’s a great point. Even though we all believe this technology is a quantum leap forward, we still need to assess issues that could lead to contact lens-associated dryness.

Dr. Nichols: I agree. When there’s an underlying condition, a lens can’t make that go away. We need to evaluate the ocular surface and lids at every visit and manage the findings appropriately, even for a patient who says everything is “fine.”

Value Versus Cost

Dr. Eiden: From my perspective, Dailies Total1 lenses are for everybody whose prescription fits the parameters. Do you agree? Will this lens be a problem-solver or a go-to lens in your practice?

Dr. Kassalow: I will clearly position Dailies Total1 contact lenses as a go-to, first-reach lens. It is a premium lens with a premium-lens price, so some people may push back because of the cost and stay with products that are less expensive. In those cases, I’ll use it as a problem-solver when appropriate.

Dr. Eiden: How have patients responded so far to the higher cost of this new technology?

Dr. Schachet: Reactions have been mixed so far. It wouldn’t be fair to say it has been accepted overwhelmingly; however, I recently had an interesting case. Some long-time patients came in with their sons, ages 13 and 15 years. They had been wearing contact lenses, but not very comfortably. When they tried Dailies Total1 lenses, both boys had an overwhelmingly positive experience. This was the first time they’d been able to wear contact lenses all day. I explained the cost to their parents. I guess they went home and thought it over, because 3 days later, they called and ordered Dailies Total1 lenses for both boys.

Dr. Eiden: Practitioners often wonder: Should we or shouldn’t we discuss the cost before the patient experiences the lens? I’ve decided I want my patients to experience the lens first. I do mention the cost is a bit higher, but I tell patients, “I don’t want to talk about the cost now, because I don’t want that to influence how you respond to this lens. I just want you to experience it. If your experience is as positive as I expect it to be, then we’ll have that conversation. You can decide if the value is worth the price.”

Dr. Jasper: I think patients hear “new technology” and “innovative contact lens,” and they know it will cost more. I’m okay with that. I’m not going to prejudge a patient’s ability or willingness to pay for a premium product. Those of us who have opticals, encourage our staff to present the best frames to everybody, so why would we not present the best medical device to everybody. In the end, patients know I did not prejudge them, and I treated them like my best friend and my family.

If you design your marketing properly and let people know this truly is a revolutionary new contact lens, there’s absolutely nothing like it anywhere in the world, I think you’ll have quite a few people coming in to try it.

— John L. Schachet, OD
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A recently concluded study demonstrated that patients enrolled in the OPENINGS™ Program who used the savings card filled an average of two additional prescriptions compared to those not enrolled in the program. Those who enrolled but did not use the savings card or may not have used it because they participate in a government-funded savings program, filled an average of one additional prescription a year. In light of this, make the OPENINGS™ Program part of your patient care plan.

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* Online quantitative survey with patients currently using active ingredient. The Test group consisted of 220 patients enrolled in the OPENINGS™ Program while the Control group included 151 patients not enrolled in the OPENINGS™ Program and not using the Alcon Savings Card. Statistical testing was performed at the 95% Confidence Interval.
Groundbreaking Technology

Dr. Eiden: What does the introduction of Dailies Total1 lenses mean to you and your practice?

Dr. Nichols: If everyone’s experience is similar to my own with this lens — being able to wear it comfortably longer than any other daily lens, having minimal lens awareness, yet maintaining good quality vision — then this technology is going to impact the daily market. I think it could revolutionize how we think about the technology behind daily disposable contact lenses, and how we select lens options for patients, including patients with comfort issues.

Dr. Schachet: This is a unique lens that should be in a category all alone. There isn’t anything like it anywhere. When my patients try it, I simply say, “If this lens isn’t the most comfortable lens you’ve ever put on, I’d like to hear why.”

Dr. Kassalow: We’ve learned that almost 50 percent of people who stop contact lens wear do so because of discomfort issues, and I can’t assume that my practice is any different. If we can reduce that number in our practices, it will have a ripple effect and help us grow exponentially. I think it’s going to have a huge impact on my practice, because fewer patients will leave contact lens wear.

Dr. Brujic: We’re taking comfort to the next level with this lens, and I think that’s an exciting place to be, because comfort is an unmet need in our patient populations. We now have this new tool to help us keep more patients in contact lenses.

Dr. Jasper: I’m excited about this lens, because, to me, it means I have a slam-dunk, a lens that will take care of my patients’ needs. I love being able to tell my patients, “I’m going to give you the best lens in every category. It’s also going to give you the best vision.” This lens makes me look good, and it makes my patients extremely happy.

Dr. Eiden: Dailies Total1 lenses represent groundbreaking technology that will enable us to address our patients’ comfort and vision needs — the whole package. I know I speak for the panel when I say we’re honored to have been part of the initial group of practitioners to have access to this technology and to experience it. Now, it will be equally as exciting for us to share it with our colleagues.

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

References
Setting the Stage for Daily Disposable Contact Lenses

It’s easy to say patients will benefit from daily disposable contact lenses, but it’s more difficult to go out there on a daily basis and discuss this. Recommending and refitting everyone requires time and energy from the doctor and staff. This may be especially difficult when your practice has a full schedule. You need a unified approach to discussing daily disposable lenses, especially for patients who present with no complaints in their current contact lens prescription.

Break the Ice

If you believe in the daily disposable concept and a patient presents with no complaints and just wants to renew his contact lens prescription, consider at least setting the stage for a daily disposable refit. Use a simple introduction such as, “Your contact lenses are working great, but you may want to consider trying daily disposable lenses.” I usually go on to explain how the cost is virtually a break-even when you consider manufacturer rebates and no need to buy care solutions. A patient may ask, “but how much do they cost?,” which leads right into our pricing strategies.

Pricing Strategies

Proper pricing strategies help set the stage for daily disposables. You can even turn the price discussion into one easy sentence, “cost savings, manufacturer mail-in rebates and in-office instant rebates will counteract the price difference and may even save you some money when compared to reusable lenses.” I usually go on to explain how the cost is essentially a break-even when you consider manufacturer rebates and no need to buy care solutions. And then there’s the most important commodity — your time in not having to care for contact lenses!

1. Remove pre-conceived obstacles!

First, consider removing your obstacles. Many eyecare professionals assume patients don’t want daily disposable contact lenses because of the presumed cost increase to the patient. It’s important to understand that whatever the dollar difference, many patients are willing to accept it when they recognize the value of the product. Many of us use these techniques with regard to optical sales, but they also apply when discussing daily disposable contact lenses:

Don’t avoid the issue of price: Talk about the price up front.

Explain the value equation: Daily disposable contact lenses provide improved convenience. Patients don’t have to worry about the extra costs associated with other modalities, such as buying solutions. If they rip or tear a lens, they haven’t substantially increased their costs.

2. Discuss the price after factoring in rebates and solution cost savings!

Many online stores will quote prices after rebates, cost savings and/or discounts. Applying the same principal to daily disposable contact lenses, we could take these factors into the price equation:

Try new pricing and promotional strategies: Consider discounting per box retail price for annual supply purchases. I call that an In-Office Instant Rebate. The price yielded on higher sales volume will offset any margins lost on a per box purchase.

Make it easy for the patient to do business with you: Offer free direct-ship for all daily disposable orders. Many patients will take advantage of the large manufacturer rebates.

Develop a Goal

Take a snapshot of where your current daily disposable sales are as a starting point. Most distributors or manufacturers can provide your total daily disposable sales as a percent of overall contact lens sales. Use those numbers to take a unified approach to moving your numbers in a specified direction. The daily disposable modality is a great product to consider renewing your practice’s contact lens focus.

Dr. Miller is in a partnership private practice in Powell, Ohio, and is an adjunct faculty member for The Ohio State University College of Optometry. He has received honoraria for writing, speaking, acting in an advisory capacity, or research from Alcon, Allergan, CooperVision, and Visioneering Technologies. You can reach him at drmiller@eyecarepowell.com.
Winning the Race

The first person to cross the finish line wins the race. That’s a truism in running, swimming, cycling and car racing. And, in my experience, it’s a safe bet that the first eyecare practitioner (ECP) to cross the finish line wins the race too. Of course, the race and finish line for an ECP doesn’t involve the waving of a checkered flag. Instead, it means increased profits and a healthier, more vibrant practice.

Winning in Practice
But what’s our equivalent of the race and finish line? It awaits practitioners with the foresight, wisdom and business acumen to realize the benefits of bringing “firsts” to their patients; being known in their communities as the go-to guy or gal for everything new in eye care. And the first we’re talking about here is new contact lens technology. As in sports, the first one wins. In this case, the first ECP to offer the latest technology to his patients, and those patients who benefit from the technology, are the winners.

Why Winning is Important
If you’re the first ECP in your area to offer a new technology contact lens, your patients are more likely to perceive you as ahead of the curve compared to others.

It’s just plain common sense to think that those who offer new technology first are technologically ahead of those who do not. This perception of being an expert percolates down to all aspects of your practice. “If they offer the latest contact lenses, they must do everything else really well too.” You wouldn’t expect a cardiac surgeon who performs the latest surgical procedure to offer leeches as an alternative therapy. An extreme example? Yes, but it proves the point. Patients in offices offering new technology don’t expect, and won’t receive, HEMA lenses. In fact, we often define and judge our peers based on their proclivity to embrace and espouse new technologies. If we do it, don’t you think our patients will, too? In other words, impressed patients will spread the word, and free word-of-mouth marketing is the best kind.

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The other benefit to being the first to offer new technology is an economic one. Early adopter patients gravitate to early adopter ECPs. As such, they aren’t deterred by slightly higher prices. Offering patients the newest in contact lens technology might not get you an Apple iPhone line outside your office, but conceptually, the idea is the same. Satisfied patients = long-term patients, and long-term patients generate more income and loyalty over time. This is Economics 101 and it’s been demonstrated hundreds of times. We’ve heard stories of people who paid hundreds of dollars for calculators in the seventies, but what about the stories of those who SOLD those calculators? They enjoyed a nice economic ride because they were among the first to offer “new technology.”

Check Your Opinion at the Door
A key point to winning and being first is that it is the patient, not the ECP, who ultimately decides if the race is even worth running. It is the patient who will determine if the added benefits of a new contact lens are worth the entrance fee to participate in the race. It is NOT and should not be the ECP’s place to decide this for the patient. Doing so will cost your practice thousands of dollars. Prejudging a patients’ desire to acquire and pay for new technology can be the costliest practice-building mistake you can make.

Your Trophy Awaits
The race is yours to win or lose. But to do either, you have to participate. And if you participate NOW, the odds of winning are astronomically high! CLS

Dr. Gerber is the president of the Power Practice, a company offering proven and comprehensive practice and profit building systems. You can reach him at www.PowerPractice.com and follow him on Twitter @PowerYourDream.
Why Daily Disposable Lenses Make Sense for Children

Daily disposable lenses offer a number of advantages for children, and parents often appreciate the advantages of convenience and compliance. They also want the best visual performance for their children and may worry about the child’s level of responsibility. Doctors often feel more comfortable fitting children in daily disposable lenses, too (Sindt, Riley 2011). With the simplicity of the daily disposable replacement system and the benefit of enhanced compliance (Dumbleton 2009), it’s no surprise that children are prescribed the highest proportion of daily disposable contact lenses (Efron 2011).

Optimizing Vision
Most common pediatric prescriptions are available in daily disposable lenses, and several studies have found that these lenses provide better vision compared to reusable daily wear soft lenses, with fewer symptoms of cloudy vision (Nason et al 1994, Solomon et al 1996, Fahmy et al 2010). Furthermore, myopic children under 12 report better vision-related quality of life when fit with contact lenses compared to eyeglasses (Rah et al 2010).

Improving Comfort
Comfort is enhanced by placing a fresh lens on the eye each day, thereby eliminating biofilms that may build up in a lens case (Chalmers et al 2012). Lens deposits may lead to symptoms of dryness and discomfort. Daily disposable hydrogel lens wearers have fewer toxic and hypersensitivity reactions (Radford et al 2009) than reusable lenses, and these lenses have been shown to improve the signs and symptoms of tired, irritated eyes, blurred vision, redness, discomfort, deposits and dryness (Fahmy et al 2010).

Replacing the lens daily reduces the build-up of denatured proteins and other antigens that accumulate on the lens during wear. In one study, some patients reported they were able to discontinue allergy medications when using daily disposable contact lenses (Hayes et al 2003).

Better Compliance
Poor patient compliance may lead to adverse events, and poor compliance with care regimens is rampant among contact lens wearers. But daily disposable lenses require only proper hand-washing prior to insertion and removal. It may be difficult for parents to monitor their child’s compliance, so reducing the number of steps to maintain compliance makes parents and doctors more confident that children will be able to enjoy contact lens wear without problems.

Cost Comparison
Children are more likely to engage in part-time contact lens wear (Efron et al 2011), and daily disposable lenses are less expensive when worn 1 to 4 days per week compared to reusable lenses. They equal the cost of reusable lenses at 5 days per week of wear and are slightly more expensive when worn full time (Efron et al, 2010). Parents appreciate having replacement lenses on hand in case children damage or tear lenses. Overall, many parents feel the benefits of safety and compliance outweigh any cost concerns.

From comfort and convenience to improved vision, daily disposable lenses are a great vision correction option for pediatric patients. CLS

For references, please visit www.clspectrum.com/references.asp and click on document SE2013.

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Contact Lens Discomfort: Can Past Workshops Provide Insight?

Contact lens-related discomfort, especially late in the day or after prolonged near activities, is a significant problem for many of our patients. My column usually focuses on the frank treatment of anterior segment and contact lens conditions. In this column, I will summarize what we know about contact lens-related irritation based on what we’ve learned from the DEWS Report and the MGD Workshop. The DEWS report cited contact lens discomfort and dryness as primary reasons why our patients become less tolerant of contact lens wear (DEWS Report). Some of these patients are known (complainers) and some unknown (silent tolerators) to our staff and ourselves. The former are likely to drop out of contact lens wear entirely. Between 50 and 75 percent of all patients complain of some form of ocular irritation while wearing contact lenses (DEWS Report). Dropout rates for contact lens wearers have been reported to be between 12 and 28 percent, depending on the criteria used in the particular study (Schlanger, 1993; Weed et al, 1993; Pritchard et al, 1999; Young et al, 2002; Richdale et al, 2007; Rumpakis, 2010; Dumbleton et al, 2013). More troubling is that despite advances in lens materials, wetting agents and designs, not much has changed over several decades with regard to contact lens comfort.

According to the 2007 DEWS Report, dry eye as defined by the report is broadly defined as aqueous (Sjogrens or non-Sjogrens) and evaporative (MGD). Contact lenses are seen as extrinsic factors that affect the tear film, causing evaporative effects. This may be the result of a thinning of the pre-lens tear film or an insufficient wetting of the contact lens surface, both of which affect tear film stability on the anterior surface of the contact lens. Material properties may lead to wettability issues with additional issues caused by lens deposition in the form of denatured protein and lipids. This can be addressed using adequate lens care regimen compliance, but also through the prescribing of daily disposable contact lenses. Although contact lenses cause evaporative effects, they may also disturb aqueous production through a sensory reflex block mechanism. Higher water contact lenses have been associated with dryness, however this has not been a universally accepted truth and thus remains controversial within the field (DEWS Report).

Additional information about the effects of contact lens on the tear film as they relate to the meibomian gland is described in the MGD workshop report. (Knop et al, 2011) As reported, because of its action on the meibomian gland, estrogen treatment can lead to tear film instability and reduced contact lens tolerance (Knop et al, 2011). Contact lenses may also cause epithelial keratinization as well as meibomian gland orifice obstruction that can further complicate successful wear. It has also been noted that contact lens wearers have a high meibomian gland dropout rate that may be related to the keratinization cycle, however the precise mechanism is not known. This dropout rate mimics what is found in the normal aging process. A critical reading of two well regarded published reviews on ocular dryness and meibomian gland dysfunction may help in addressing many issues that affect contact lens patients. Further management in the form of topical drops, contact lens care systems and novel contact lens technologies may further help more patients stay comfortable throughout the day, reduce intolerance and limit drop outs.

For references, please visit www.clspectrum.com/references.asp and click on document SE2013.

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*In vitro measurement of unworn lenses.
2. Based on critical coefficient of friction measured by inclined plate method; significance demonstrated at the 0.05 level. Alcon data on file, 2011.
3. In a randomized, subject-masked clinical study, n=40. Alcon data on file, 2011.

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