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**NovaKone® Soft Lens**
- Dual Elliptical Stabilization™ and cylinder powers to -10.00D, to help address residual astigmatism in patients with keratoconus
- Variable lens center thickness to help neutralize irregular astigmatism

* Fellow of Contact Lens Society of America

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Bausch + Lomb (B+L) and has received research grants/contracts from B+L and Paragon Vision Sciences.

Dr. Michaud graduated in 1986 from École d’optométrie de l’Université de Montréal, from where he later obtained his Master’s Degree in physiology. He is a full professor and has served as the chief of the contact lens department at Université de Montréal since 2001. Dr. Michaud is a consultant/advisor to Blanchard Laboratories; has received research grants/contracts from Alcon, Genzyme, and Johnson & Johnson Vision Care; travel reimbursement from Blanchard and Synergeyes; and lecture/authorship honoraria from Allergan, Bausch + Lomb, Blanchard, CooperVision, and Genzyme.

Muriel Schornack, OD

Dr. Schornack is a consultant in the department of ophthalmology at the Mayo Clinic in Rochester, MN, and is immediate past president of the Scleral Lens Education Society. She is a Bausch + Lomb advisory board member.

Dr. Barnett is a principal optometrist at the UC Davis Eye Center in Sacramento, CA. She is an internationally recognized key opinion leader, specializing in anterior segment disease and specialty contact lenses. She lectures and publishes on dry eye, anterior segment disease, contact lenses, and creating a healthy balance between work and home life for women in optometry. Dr. Barnett is president of the Scleral Lens Education Society, a fellow of the American Academy of Optometry, a diplomat of the American Board of Certification in Medical Optometry, and serves on the Board of Women of Vision, Gas Permeable Lens Institute, and the Ocular Surface Society of Optometry. She is a consultant/advisor to Acculens, Alcon, Allergan Optical, Bausch + Lomb (B+L), Contamac, CooperVision, Johnson & Johnson Vision Care (J&J), NovaBay, and Paragon Biotech. She has received travel reimbursement from Alcon, Alcon, Allergan Optical, Allergan, Bausch + Lomb (B+L), Contamac, CooperVision, Johnson & Johnson Vision Care (J&J), and Paragon Biotech, Shire, and Visionary Optics.

Dr. Jedlicka is a clinical associate professor at Indiana University School of Optometry and director of the Cornea and Contact Lens Service. He is a diplomate in the American Academy of Optometry’s Cornea, Contact Lens, and Refractive Technologies section, a past president of the Scleral Lens Education Society, and a fellow and board member of the Contact Lens Society of America. Dr. Jedlicka has lectured internationally and written many articles and book chapters on contact lenses and anterior segment disease. He is a consultant/advisor to Bausch + Lomb, and has received travel reimbursement and lecture/authorship honoraria from Essilor Contact Lens and X-Cel Specialty Contacts.

Dr. Johns is a graduate of the New England College of Optometry, where she also completed a residency in cornea and contact lenses. She won the national Dr. Sheldon Wescieder contact lens residency award in 2005. After her residency, Dr. Johns joined the Boston Foundation for Sight, where she served as the senior optometrist for 8 years, designing and fitting specialty lenses and managing complex corneal disease. She collaborated with the University of Rochester to correct higher-order aberrations in keratoconus patients with scleral lenses. Dr. Johns is a fellow of the American Academy of Optometry and the Scleral Lens Education Society. In 2013, she returned to the New England College of Optometry as an adjunct assistant professor with the Contact Lens service. She is a consultant for Bausch + Lomb Specialty Vision Products.

Dr. Lipson is an assistant professor at the University of Michigan’s Kellogg Eye Center, Department of Ophthalmology and Visual Science, at the Northville location. His clinical practice emphasizes specialty contact lenses for overnight corneal reshaping, keratoconus, post-corneal transplant, post-refractive surgery, and severe dry eye patients. Dr. Lipson is the vice president of the Scleral Lens Education Society. He is a consultant to Bausch + Lomb (B+L) and has received research grants/contracts from B+L and Paragon Vision Sciences.

Dr. Michaud graduated in 1986 from École d’optométrie de l’Université de Montréal, from where he later obtained his Master’s Degree in physiology. He is a full professor and has served as the chief of the contact lens department at Université de Montréal since 2001. Dr. Michaud is a consultant/advisor to Blanchard Laboratories; has received research grants/contracts from Alcon, Genzyme, and Johnson & Johnson Vision Care; travel reimbursement from Blanchard and Synergeyes; and lecture/authorship honoraria from Allergan, Bausch + Lomb, Blanchard, CooperVision, and Genzyme.

Dr. Schornack is a consultant in the department of ophthalmology at the Mayo Clinic in Rochester, MN, and is immediate past president of the Scleral Lens Education Society. She is a Bausch + Lomb advisory board member.
Scleral lenses have a longer history than any other type of contact lens. Conceptualized by Leonardo DaVinci in the early 16th century and first fabricated in Europe in the late 1800s, scleral lenses have been in development for centuries. DaVinci’s idea of neutralizing the eye optically with an enclosed liquid reservoir eventually developed into a legitimate contact lens with widespread applications due to oxygen permeable polymers and computer-driven, diamond-tipped lathes.1 These developments have allowed scleral lenses to overcome their previous shortcomings — mainly lens-induced corneal edema and poor reproducibility.

HISTORY OF SCLERAL LENSES

All along, scleral lenses have provided known benefits, such as protecting the fragile ocular surface from exposure to and damage from the outside world. Lens comfort was rarely a problem, and vision correction with rigid optics and a fluid filled reservoir was exceptional. The first reported scleral lenses were made of blown glass (Figure 1) by F. A. Mueller in 1887, and were used to protect corneas from various conditions that led to exposure, thus demonstrating the potential in managing ocular surface disease.2 The following year, both Eugene Fick and Eugene Kalt began describing the use of scleral lenses with optics added to correct vision, and within a year, August Müller had fabricated a scleral lens to correct his own high myopia, demonstrating the ability of scleral lenses to correct vision, even in complex refractive situations.1-4

Blown glass lenses were utilized into the early 1900s, but were fraught with problems, including limited wearing time due to lack of oxygen permeability and a short life-span for the lens, which was a major problem since reproducibility was difficult. By the 1930s, the transition to using plastic had begun, with the introduction of PMMA scleral lenses.5 Plastic had many advantages over glass, including a lower mass, improved durability, and ease of manufacture. However, there were still problems that went unresolved, namely hypoxia, and when corneal PMMA lenses were developed in the late 1940s, scleral lenses saw their role in vision correction quickly dissipate.

In the 1980s, scleral lenses began to demonstrate new relevance due to improvements in lens materials. The introduction of oxygen permeable lens polymers, even low Dk materials at the time, began to bring about a change in use of scleral lenses. Pioneers — namely Don Ezekiel in Australia, Ken Pullum in the United Kingdom, and Perry Rosenthal in the United States — developed their own scleral lens designs and reported promising results.6-9 The success obtained with scleral lenses motivated others, and by the mid 1990s, widespread growth of scleral lens usage had begun.

By the early part of the 2000s, high and hyper Dk lens materials and reproducible designs allowed for better ease of fitting, healthier lens wear, and the development of fitting sets. All of these factors allowed greater numbers of practitioners to use scleral lenses. Scleral lenses became commonly found at major university medical centers, while commercial designs, such as the Jupiter scleral lens, started to evolve. By the second decade of the 21st century, scleral lenses had become increasingly common in private practices and since then, have become a necessary tool in the hands of the specialty contact lens practitioner, bringing a new level of interest and excitement to the GP lens category.

GROWTH IN POPULARITY

The growth in usage of scleral lenses has been steady and remarkable for a category of lens once thought to be dying off. With the popularity of scleral lens lectures,
**INITIAL BASE CURVE SELECTIONS**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Base Curve Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keratoconus</td>
<td>1.0 D flatter than average K</td>
</tr>
<tr>
<td>Normal Corneas</td>
<td>On Flattest K</td>
</tr>
<tr>
<td>Post Lasik</td>
<td>4.0 D Steeper than Flat K</td>
</tr>
<tr>
<td>Post RK</td>
<td>5.0 D steeper than Flat K</td>
</tr>
</tbody>
</table>

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webinars, and workshops, the resources devoted to scleral lens education, and the potential for more use among the healthy cornea population, including multifocal lenses, this growth should continue for several years to come.

**MODERN USAGE**

Modern scleral lenses have many aspects in common with their predecessors. Scleral lenses are most frequently made using materials with a Dk of 95 or higher to reduce the risk of corneal hypoxia. There are many high and hyper Dk lens materials available in today’s market, so each practitioner has the ability to choose the material that best suits the individual patient. In addition, modern scleral lenses available in the United States are designed to be fluid ventilated — in other words, filled with a fluid reservoir that does not involve lens fenestration. The other option — air ventilated — requires fenestration and has not garnered the popularity of fluid-ventilated designs.

By definition, scleral lenses fully vault the cornea as well as the limbus (Figure 2). Only when a scleral lens is improperly fit or when an eye has changed would cornea and lens contact occur. The lens mass is designed to rest on the conjunctival-scleral complex, where the eye is much less sensitive and scarring does not impact vision. By fully vaulting the cornea and maintaining a fluid reservoir between the lens and the cornea, scleral lenses can protect a compromised cornea or greatly improve vision in even the most distorted corneas.

**THREE ZONES**

When considering the design of a scleral lens, there are three zones, each one somewhat independently adjustable. These three zones are the optical zone, the transition zone, and the landing zone (Figure 2). There may be other terms used for these different zones depending on the manufacturer, but all have essentially the same concept. The optical zone is the central aspect of the lens that carries the prescription for correcting vision, as well as the bulk of the area of corneal vault. This zone has a radius of curvature as well as a diameter, which often can be manipulated to adjust the power and amount of vault. The optical zone vault, in most cases, should provide adequate but not excessive vault in all areas of the fit, as excessive vault hinders oxygen transmission and inadequate vault can lead to corneal mechanical compromise and, eventually, corneal scarring.

The outermost aspect of a scleral lens is the landing zone, scleral zone, or haptic. This is the area of the lens that rests upon the conjunctival-scleral complex. This region of the lens will typically consist of two or three different curves, or, in some designs, may have a linear or tangential zone. The landing zone will press down upon the sclera with all the lens as well as lid pressure. For this zone to properly fit, it should match the scleral shape as closely as possible to maximize the surface area of contact and distribute the pressure evenly. This zone can be made with toric curves, and, in some designs, can be quadrant specific or freeform to optimize alignment.

The zone between the optical zone and landing zone is the transition zone. This zone simply serves to bring together a properly vaulting optical zone with a properly aligned scleral zone, while maintaining the fit. The transition zone typically will demonstrate the greatest vault at the edge of the optical zone and taper to insignificant vault at the start of the landing zone. This zone usually vaults over the limbus — a vital region for ocular health — so ensuring a proper fit of this zone is crucial.

**APPLICATIONS**

Scleral lenses have many applications, both for the correction of vision, as well as the healing and protection of the ocular surface. Because scleral lenses vault the cornea, they are an ideal option for irregular corneal conditions that diminish vision, such as keratoconus, corneal dystrophies and degenerations, pellucid marginal degeneration, post-surgical irregular astigmatism, and corneal scars. Because of the liquid reservoir and size, scleral lenses can protect and heal the ocular surface in cases of exposure, neurotrophic, or other forms of keratopathy, as well as severe dry eye. As a result of the excellent comfort and vision provided by GP optics, scleral lenses are increasingly being considered for simple correction of refractive error.

The Collaborative Longitudinal Evaluation of Keratoconus (CLEK) study demonstrated that corneal GP lenses are associated with scarring in keratoconus. Because scleral lenses do not touch the corneal surface when properly fit, the likelihood of a scleral lens causing corneal scarring would appear to be reduced (Figure 3). In addition, the stability of scleral lenses on a keratoconic eye opens the door for the possibility of higher order aberration control. Finally, because of their comfort and stability, many patients with keratoconus can enjoy increased wearing time, which is helpful considering many cannot successfully use eyeglasses when lenses are removed.

Similar to keratoconus, scleral lenses have application with individuals with pellucid marginal degeneration, as...
this condition also distorts vision and is perhaps even more difficult to fit with a corneal GP because of the location of the steepest area of the cornea. For post-surgical patients that require a reverse geometry GP lens but still struggle with lens decentration, instability, and discomfort, scleral lenses can provide a stable, comfortable fit that improves vision and does not contact the sensitive post-surgical cornea. In individuals with other corneal pathologies that have reached the point of affecting vision, scleral lenses can provide visual improvement without further disturbing a damaged cornea.

Ocular surface disease (OSD) management is another great benefit of scleral lenses over corneal GP lenses. The management of OSD is effectively accomplished because the lens shields and shelters the ocular surface from the outside world, while constantly bathing the ocular surface in a liquid reservoir. Filling solutions can include non-preserved saline, non-preserved artificial tears, and, in some cases, other agents, such as autologous serum, to help heal the compromised cornea.

Management of OSD does not end with lens fitting, however, as the lens surface may dry, deposit, and demonstrate poor wettability because of OSD. Thus, OSD patients require ongoing care. However, the cornea is protected, which often improves symptoms and vision (Figure 4).

For more on this topic, see “Managing OSD with Scleral Lenses” on page 18.

SCLERAL LENS USAGE IN NORMAL CORNEAS

There is some controversy as to whether scleral lens usage should be widespread in normal corneas. Some believe that the benefits — GP optics, liquid reservoir protecting the ocular surface, a stable and comfortable lens — justify increased usage in patients with more complex refractive error or presbyopia. Others feel there are too many unknowns to subject patients with other options to potential low levels of corneal edema. Better long-term studies will help direct the use of scleral lenses in the general population.

CAUTIONS

Despite the benefits of scleral lenses, there are instances in which scleral lenses should be used with caution. Individuals that may be at risk for corneal edema, such as those post-penetrating keratoplasty or with endothelial dystrophies, must be monitored carefully for edema or other signs of hypoxia, such as neovascularization. Additionally, the patient with fragile epithelium, such as anterior basement membrane dystrophy, may be at an increased risk for abrasions or erosions, either in the application or removal process or through weakening of the epithelium by continuous bathing in saline for many hours. These are not absolute contraindications, but rather instances to proceed with caution.

BRIGHT FUTURE

In my opinion, scleral lenses are an amazing, life-changing tool in the eyecare practice. From healing a sick eye to providing healthy all day vision to individuals with irregular corneas, scleral lenses have revolutionized how many of us practice on a daily basis. Scleral lenses can invigorate you professionally and provide satisfaction for you and your patients. The future is bright for modern scleral lenses.

For references, please visit www.clspectrum.com/references and click on document #SCLERAL2016.
At the end of a recent lecture, I was about to leave the room when one of my students came forward. “Sorry to keep you late, but you told us we have to consider scleral lenses as the future of the contact lens market. I’m struggling to see that happening anytime soon. I don’t believe that, at a given point, they will replace daily disposable lenses. Did I miss something? Are there that many patients with keratoconus?” The following is a summary of my answer.

**BUSTING THE MYTH**

In the past, scleral lenses were mostly fit to treat ocular surface disease and visual correction for irregular corneal astigmatism. However, with the recent evolution in designs and manufacturing processes, and considering their main characteristics, it would be a mistake to keep them as niche products, prescribed only by a few contact lens experts.1 Fortunately, the trend is headed in a different direction. The rebirth of the scleral lens modality is due in part to proactive practitioners who are thinking outside the box and looking to explore other patient conditions that can benefit from scleral lens technology. It is time to bust the myth that scleral lenses are specialty contact lenses used only with special corneas. They are, in fact, becoming mainstream.

**SCLERAL LENSES: WHAT THEY CAN OFFER**

This modality can offer many different positive outcomes compared with other ones, especially in fixing two major issues that often lead to dropout: vision and comfort.2 In general, scleral lenses have been known to help optimize visual acuity. They are made of rigid gas permeable (GP) materials known to be optically superior to any other type of material.3 Scleral lenses help to lower high-order aberrations through optical correction and better compensation of surface irregularities. Also, scleral lenses are designed with a larger optic zone that doesn’t interfere with a larger pupil diameter. Consequently, fewer halos and less glare are experienced due to lighting conditions or when driving.

Another important aspect is that scleral lenses move minimally once stabilized on the ocular surface. To provide good visual acuity, they also have to be well centered. This is easier to achieve with smaller diameter scleral lenses. Given the conjunctival anatomy and gravity, larger scleral lenses tend to decenter inferior (downward) and temporal, leading to a misalignment.
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Numerous Applications

- Normal Prolate Corneas
- Presbyopia
- Astigmatism
- Emergent or Fruste Keratoconus
- Soft & GP Lens intolerant
- Post-RK, Post-Lasik
- Nipple Cones
- Oval Cones
- Irregular Corneas
- Ectatic Corneas
- Ocular Surface Disease

Countless Benefits

- Crisp, consistent vision & hydrating comfort
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between the visual and optical axis, which contaminates visual perception. This element becomes crucial when correcting for presbyopia. Smaller diameter scleral lenses (15.5 mm or less) are usually preferred for normal corneas and healthy eyes.

Scleral lenses can also help improve the contact lens experience by enhancing short- and long-term comfort. First, scleral lenses don’t touch the cornea or limbus, which are two of the most sensitive parts of the body. When blinking, they also limit lens-to-lid interaction, which is the main cause of discomfort with small diameter GP lenses.

Higher lens coefficient of friction is thought to be associated with contact lens discomfort. Rolflucoslon A and E, and Hyfocon A materials are characterized by a very low wetting angle. This implies that the tear film can spread easily on the surface with minimal surface tension. Consequently, this lowers the amount of deposits on the lens surface, at least in healthy eyes without meibomian gland dysfunction and blepharitis. Lens moisture can also be improved with plasma treatment. Moreover, if hydrogen peroxide is used as a care regimen as directed without rubbing of the lens, plasma treatment will remain unaltered for several months. With an abrasive contact lens cleaner, plasma treatment may last 30 to 45 days. In my opinion, the new Hydra-Peg surfacing technology can also be considered as a good alternative to improve lens resistance to deposits.

Finally, scleral lenses never dehydrate, and the presence of the post-lens fluid reservoir helps to keep the ocular surface moist during all wearing hours, which enhances patient comfort.

**RISK-BENEFIT RATIO**

To have a patient switch from soft contact lens wear, or to consider fitting scleral lenses on a naive patient, we must identify a benefit or an unmet need that will be fulfilled with scleral lenses. The risk/benefit (R/B) ratio should be evaluated for every patient.

Benefits from scleral lens wear have been documented. For diseased eyes or irregular corneas, the R/B ratio is low, meaning that benefits outweigh the risks by a high proportion. Thus, in those situations, scleral lenses are considered a safe device, as long as they are not worn overnight. This ratio can be different for healthy eyes.

As for the risks, theoretical calculations suggest that scleral lenses are linked to the presence of central chronic corneal hypoxia (2-4%), if the lenses are too thick (>250 μm) and the central clearance is too high (>200 μm). With a clearance of 400 μm, there is 33% less oxygen delivery to the cornea than with a clearance of 200 μm. At this point, studies have not yet predicted the clinical outcome of such chronic hypoxic stress on normal and healthy tissue. However, a few case reports mention the negative impact of chronic edema when the cornea is compromised after surgery or with a reduced endothelial cell count of less than 1,000 cells/mm.

Some authors compare an induced level of corneal edema to physiological edema overnight. This is misleading, because overnight physiological edema is eliminated within the first hour after awakening, and the cornea quickly restores itself. Corneal edema induced by scleral lens wear continues throughout the wearing hours with no chance for recovery. In addition, if lenses are used very soon after waking, the cornea never has a chance to recover.

When it comes time to fit young, normal, healthy corneas, these elements raise the risk/benefit ratio. Fortunately, there are ways to alleviate negative outcomes, such as providing less corneal clearance and using thinner lenses.

**WHO ARE THE HEALTHY CORNEA CANDIDATES?**

First, any patient wearing soft or small diameter GP lenses who complains of discomfort or experiences visual disturbances is a prime candidate to be fit with scleral lenses. This symptomatic population represents up to 40% of patients in an optometric practice.
practice.\textsuperscript{16} The key is to proactively identify these patients, which means asking the right questions.\textsuperscript{17}

Although there have been many advances in contact lens technology, the contact lens dropout rate remains high, around 16%\textsuperscript{,17-23} As such, practitioners should dig deeper and proactively look for signs and clues to predict which patients have the potential for contact lens dropout. In my opinion, three major factors play a role: vision, comfort, and handling difficulties. Specific questions should be asked to ensure that lenses are comfortable and vision remains sharp and stable during all wearing hours, and that the lenses are easy to insert and remove.

Perhaps, ask this question: “If you could improve one thing about your contact lens experience, what would it be?” Unmet needs can be an opportunity to consider scleral lenses.

**FIRST OPPORTUNITY: HIGH REFRACTIVE ERROR PATIENTS**

Patients with high myopia, astigmatism, and hyperopia are challenging. There aren’t many contact lens options that can correct vision properly while maintaining optimal ocular health. In some cases, scleral lenses can help.

**High myopia**

For highly myopic patients, scleral lenses can improve visual acuity, because a larger optic zone can be used and, thus, won’t interfere with the patient’s pupil diameter. With soft lenses, the spherical optic zone is limited to 6 to 7 mm, or even smaller if combined with a toric design. It is not rare to see moderate to highly myopic patients display a pupil of the same size as the optic zone. Under low illumination, the pupil dilates and expands outside of the optic zone, generating haloes and glare. With a larger optic zone of 8 to 10 mm, scleral lenses are a better alternative to improve visual acuity. The lens optic zone is large enough that it won’t interfere with the patient’s pupil.

It is possible to further improve the vision of highly myopic patients (>-6.00D) by relying on an oblate scleral lens design. A Q value is equal to 0 because the radius is constant. There is no flattening of the curve from the center to the periphery. A prolate cornea, which is a parabola, generates a negative Q value of -0.25, because its periphery is flatter than the central curvature. In young patients, the crystalline lens also induces -0.25 Q value. A total negative Q value is linked to higher levels of spherical aberrations, which impact the image quality perceived by patients. The higher the refractive error, the more negative the impact.

An oblate surface generates a positive Q value. In theory, this can counterbalance the natural negative Q value of the eye, especially in younger patients. Therefore, an oblate lens fit on a prolate cornea is expected to reduce spherical aberration and improve the optical outcome. Thus, the higher the refractive error, the greater the benefit.

An oblate scleral lens also has a flatter base curve compared with a corresponding prolate lens. Similar to a smaller diameter GP lens, the power of the scleral lens is determined by its radius or base curve and thickness. In smaller diameter GPs, contact lenses can be fit slightly flatter than the cornea without risking warpage of the ocular surface. With a scleral lens, a lens with the same sagittal height but with a flatter base curve can be designed because the lens doesn’t touch the cornea. Depending on the design or the manufacturer, the gain could be up to 5 diopters. Consequently, a patient needing a correction of -10.00D can be prescribed an oblate scleral lens of -6.00D and still see better.

Another advantage of lowering the amount of minus power is that minification will be reduced. The image size perceived by the patient is 7-10% bigger with a -6.00D vs -10.00D correction.\textsuperscript{24} The higher the initial refractive initial error, the greater the gain. This undoubtedly contributes to enhancing visual acuity and is also useful when correcting presbyopia. It is preferable to rely on a -6.00D, +2.25, compared with a -10.00D with the same add power.

Enhancing vision with oblate designs makes sense, albeit fitting scleral lenses in Asian eyes can be challenging due to small interpalpebral fissures. Smaller diameter scleral lenses must certainly be considered. In addition, the ocular surface of Asian eyes is unlike those of Caucasian eyes.\textsuperscript{25} In Asian eyes, the cornea is smaller, generating less sagittal height for the same corneal curvature, the mid-periphery is more prolate, but the limbal zone and the transition with the conjunctiva is kept the same. Overall, traditionally designed scleral lenses do not fit adequately on Asian eyes and tend to significantly decenter temporally. Thus, Asian eyes require a customized design, which is available at this time in
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- quadrant specific system allows adjustments to multiple zones in four different quadrants
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- creates a natural tear lens to soothe and promote corneal health
- Three zone step system makes fitting a breeze

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With an easy-to-understand three-zone fitting system, making adjustments to your lenses is a straightforward process. Using a simple step system, you can adjust the Limbal Clearance Zone (LCZ) to increase or decrease clearance and/or the Scleral Landing Zone (SLZ) to dial in a perfectly smooth landing zone designed to align to the sclera. The Custom Stable line of lenses also offer an advanced, quadrant-specific system that allows the fitter to make adjustments to both the LCZ and SLZ on an individual quadrant basis. This allows the lens to fit even the most challenging corneas.

One of the advantages of the Custom Stable is the ability to use our unique method of utilizing flat K as a means of selecting the initial starting lens from your fitting set. This technique is extremely accurate and makes it possible for anyone to enjoy great success fitting initial lenses, even if they do not have topography or OCT equipment available. Fitters also benefit from lasered diagnostic marks on the lenses that denote rotation and zone information. This makes it easy to quickly check proper landing, clearance, and rotation.

ONE LENS, EVERY EYE.

The Custom Stable is highly adaptable and is regularly used in a wide range of situations. Beyond irregular corneas that utilize the tear lens to correct vision, the Custom Stable is also very adept at bringing relief to regular corneas challenged by soft lens acuity or intolerance, as well as to those suffering hydration challenges. Because it vaults the cornea and allows a natural tear lens to form between the lens and the cornea, imperfections of the corneal surface are eliminated. As a result, eyes remain refreshed and hydrated all day long, for up to 14 hours — something that suffers of ocular surface disease have come to love. In addition to providing extreme comfort, the Custom Stable also boasts best-in-class visual acuity. Wears are often amazed at their ability to regain sight they thought they had lost forever.

TRAINING & SUPPORT

We understand the challenge fits face when learning to fit new designs. Successful fits require not only great lens design but also a skilled and knowledgeable practitioner. This is why Valley Contax invests heavily in education, training and support. The Custom Stable Training Course is a great place to start! This 17-minute video covers everything you need to know about fitting the Custom Stable and is available at valleycontax.com. We’ve also assembled a team of eight regional education consultants across the country to provide support and answer your questions anywhere. These doctors are passionate about custom lens fitting, and you’re encouraged to reach out to them today. Visit the contact page on our website for more information.

Valley Contax regularly offers hands-on training through our Custom Stable Fridays program at our state-of-the-art facility in Springfield, Oregon. These intimate sessions are perfect for the beginner who wants to learn the art of scleral lens fitting or the experienced fitter who wants to take his or her skills to the next level. When you’re fitting in practice you’re never alone — help is always available via phone, email, or chat. Our expert staff of in-house consultants is here to help you through every situation.

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prolate and oblate designs, as well as to optimize post-lasik corneas or enhance high myopia correction.

**High astigmatism**

Correction of astigmatism in general, and high astigmatism in particular, is very sensitive to the position, movement, and rotation of the contact lens on the eye. The lens must remain stable, without rotating upon blinking or in different directions of gaze. Scleral lenses are the best lenses to fulfill these requirements and they often outperform other type of contact lenses, with the exception of hybrid lenses. However, scleral lenses can compensate up to 3.5D of regular corneal astigmatism due to the post-lens fluid reservoir, which is not the case for hybrid lenses. This includes 98% of all patients with astigmatism, without physiological limitations, such as 3:00 and 9:00 staining regularly encountered with small diameter GPs.

Clinical studies have demonstrated that most astigmatic patients will perceive the difference between spherical scleral lenses and toric soft lenses. Vision is crisper and more stable with scleral lenses. The same is true for patients wearing soft toric lenses in challenging environments, including low humidity, wind, and air conditioning. However, in some cases, residual astigmatism will be present. It is important to identify the source of the residual or induced astigmatism. Contrary to general belief, a portion of residual astigmatism may come from a non-uniform tear layer under the scleral lens and the presence of lenticular astigmatism.

Larger diameter scleral lenses tend to decenter more, and, consequently, the tear reservoir adopts a prismatic shape, which is thinner on top and thicker on the bottom. Lenticular astigmatism can become apparent when corneal astigmatism is fully compensated by scleral lenses. Finally, if the lens is not supported in all quadrants, lens distortion may be induced. This happens when a larger scleral lens (16mm or more) is fit with spherical peripheral curves on a toric conjunctiva.

It is believed that induced astigmatism can come from scleral lens flexure as demonstrated by performing a keratometry/topography reading over the scleral lenses once worn. Flexure is well documented in corneal gas permeable lenses. When misalignment of the lens to corneal surface occurs, the rigid lens may bend. This bend will induce astigmatism and produce a change in lens surface keratometry. It is speculated that the blink expresses the post-lens tear fluid and the lack of fluid cannot resist against the bend in the lens. While this is reported in corneal gas permeable lenses with a variety of materials, the phenomenon has been observed with scleral lenses but has not been thoroughly investigated.

In my clinical experience, increasing the center thickness of the lens as with corneal gas permeable lenses does not reduce this occurrence but increases the risk of reduced oxygen delivery to the cornea. Just as the cornea demonstrates toricity, the scleral has asymmetry and toricity as well. Similarly, adding back surface toric curves to the scleral landing zone improves overall scleral alignment and has been observed to reduce presumed lens flexure and induced astigmatism.

There are three options to alleviate induced flexure. The first option is to make the tear layer more uniform in shape. The second option is to design toric peripheries instead of spherical ones when the conjunctiva displays 1.00D or more toricity. Finally, if residual astigmatism is still present or if it is lenticular in origin, a front-toric scleral lens design is indicated.

**High hyperopia/aphakia**

Scleral lenses are not the most appropriate way to compensate for high hyperopia, unless there is a significant amount of corneal and refractive astigmatism involved. In fact, the associated risk of generating corneal
edema is significantly higher when very thick lenses are fit. This becomes crucial when dealing with young postsurgical aphakic patients. Small diameter GPs may be better suited in these circumstances. Regardless, careful monitoring of the corneal condition is required.

SECOND OPPORTUNITY: PRESBYOPIC CORRECTION

The most dramatic dropout rate is seen when presbyopia sets in, shortly after age 40.\textsuperscript{30} Prior to age 40, 20\% of contact lenses wearers are decreased to less than 10\% a few years later.\textsuperscript{30} Patients often quit wearing contact lenses due to poor vision and are unaware that multifocal options exist.

Another factor is the paucity of soft toric contact lens multifocals able to properly correct astigmatic presbyopes. Full correction of refractive astigmatism is mandatory to achieve a successful presbyopic contact lens fit. Masking astigmatism is not an option. Small diameter GPs or hybrid multifocal lenses can be considered; however, scleral lenses are another good option because they also address the dry eye disease that often emerges concomitantly with presbyopia. In the last 2 years, many new multifocal scleral lens designs have been launched,\textsuperscript{31} which reveals the potential market growth of this segment.

To be successful, scleral lenses should be precisely centered on the cornea. This may be easier to achieve with smaller diameter scleral lenses (15 mm or less). However, if a larger lens is needed, toric peripheral curves may aid lens centration. If lens misalignment is present, the optics of the lens can be decentered to match the visual axis, enhancing the visual outcome. This process is more complicated and requires increased chair time and laboratory consultation.

THIRD OPPORTUNITY: ALLERGY CONTROL

Almost 60\% of people with allergic rhinitis, and 40\% in the general population, present with ocular symptoms.\textsuperscript{32,33} Controlling allergen exposure is crucial when managing allergic conditions. Pollens and airborne particles are difficult to control. Oral medications have the potential to dry the ocular surface. Many patients need topical medications to control their ocular symptoms.

Contact lens wear, in general, positively reduces allergen exposure to the ocular surface. Scleral lenses can be more likely to further reduce allergen exposure because they cover the cornea and part of the conjunctiva. Once lens stabilization occurs, tear exchange is minimal. Consequently, chemical mediators released on the ocular surface during allergic reactions have less access to the area under the scleral lens. Thus, scleral lenses should be considered as an option for patients with moderate to severe allergic ocular symptoms.

FOURTH OPPORTUNITY: SPORTS ACTIVITIES

More and more people are active and involved in sporting activities. For practical reasons, many of them prefer wearing contact lenses when playing sports. Contact lenses also offer UV protection when playing outside. However, dust and wind can complicate lens wear. An astigmatic patient wearing soft toric lenses may experience lens rotation or visual fluctuation and discomfort when exposed to such conditions.

Scleral lenses shield the ocular surface from challenging outdoor conditions. Compared with soft lenses, they don’t dehydrate. Scleral lenses also maintain their parameters. Compared with small diameter GPs, they don’t become uncomfortable if dust and particles invade the space between the cornea and the back surface. Finally, some scleral lenses also offer UV protection. Scleral lenses are now used more frequently to fit athletes, even at a younger age. In these cases, the risk/benefit ratio for scleral lens wear should be carefully evaluated.

Scleral lenses also have a protective aspect. Case reports have demonstrated that scleral lenses exposed to ocular trauma can protect the cornea and ocular surface,\textsuperscript{34,35} but scleral lens wear for ocular protection is off-label. Practitioners should not recommend their usage when ANSI protective glasses are required.

A VALUABLE OPTION

I believe that scleral lenses are amazing devices that have proven their outstanding clinical value for the treatment of ocular disease and for visual correction of irregular corneal astigmatism.

The same benefits can be applied for patients with healthy corneas, especially to correct high refractive errors and/or presbyopia, to relieve ocular allergies, or to improve sports performance. Practitioners should also consider scleral lenses as an option to retain patients in contact lenses who are prone to dropping out due to vision or comfort issues.

Scleral lenses help to preserve ocular health by optimizing oxygen delivery to the cornea. Smaller diameter scleral lenses should be designed as thin as possible (<250 \(\mu\)m), with appropriate clearance (<200 \(\mu\)m) whenever possible. Handling may be easier with the use of smaller diameter scleral lenses.

Scleral lenses are an excellent option for patients with healthy eyes. They have the opportunity to significantly improve the contact lens wearing experience and the patient’s quality of life with customized lens designs. I believe they truly represent a unique opportunity. ●

For references, please visit www.clspectrum.com/references and click on document #SCLERAL2016.
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Managing Ocular Surface Disease with Scleral Lenses

BY MURIEL SCHORNACK, OD

Although the primary indication for scleral lens prescription reported in the literature is optical correction for patients with corneal irregularity,1-7 scleral lenses were used to manage ocular surface disease (OSD) even before the introduction of rigid gas permeable lenses. In 1943, Klein described the use of scleral shells fabricated from impression molds of the ocular surface in the management of exposure and neuropathic keratitis.8 Gould described the use of flush-fitting scleral shells for the management of the same condition in 1967,9 and later reported on the utilization of scleral lenses in the management of 66 patients with dry eye conditions.10 The use of scleral lenses in the treatment of corneal exposure secondary to thermal burns was reported by Constable in 1970.11 Shortly after the introduction of scleral lenses fabricated from rigid gas permeable materials, several papers described the benefits of scleral lens therapy for patients with OSD.12-15 Since then, a number of studies have reported improvements in corneal epithelial integrity, vision-related quality of life, and even visual acuity in patients with OSD who are treated with scleral lenses.16-20

BENEFITS OF SCLERAL LENSES

Scleral lenses are uniquely suited to treat OSD. Unlike other types of contact lenses, scleral lenses don’t come in contact with potentially fragile or compromised epithelium. Instead, the post-lens fluid reservoir continuously bathes the cornea and promotes epithelial healing. Furthermore, the lens provides a barrier between the anterior surface of the eye and the posterior eyelid, and protects the corneal epithelium from shear forces generated by eyelid movement over the ocular surface during blinking. Scleral lens wear may even affect biomarkers that have been identified in patients with dry eye disease. In a study of 26 patients with keratoconus, Carracedo and colleagues found statistically significant decreases in tear osmolarity and diadenosine tetraphosphate following 6 to 9 hours of scleral lens wear.21 This study also found an increase in MMP-9 concentration following lens wear, possibly due to the use of preserved saline in lens application. In another group of 25 patients with OSD, La Porter Weber also reported a decrease in tear film osmolarity after 12 months of scleral lens wear.22 Of interest, scleral lens therapy may improve visual acuity in patients with severe OSD.19 Immediate improvement may be noticed if significant epithelial irregularity is present, and resolution of epithelial defects and accompanying stromal edema can result in better acuity even without using scleral lenses as long-term therapy.

OCULAR SURFACE CONDITIONS

Management of specific ocular surface diseases with scleral lenses has been reported in a number of case reports, case series, and retrospective reviews. In some cases, scleral lens therapy has been cited in general reviews of systemic conditions associated with severe OSD. Conditions with the most robust bodies of supportive literature include graft versus host disease (GVHD), Stevens-Johnson Syndrome/Toxic Epidermal Necrolysis (SJS/TEN), exposure or neurotrophic keratopathy, and keratoconjunctivitis sicca secondary to chronic autoimmune inflammatory diseases (e.g., Sjögren’s syndrome and/or rheumatoid arthritis).

GRAFT VERSUS HOST DISEASE

Graft versus host disease can occur following allogeneic hematopoietic stem cell transplantation, which is used to treat various forms of leukemia. Treatment effect is obtained when transplanted T lymphocytes attack malignant tissue. Furthermore, donor cells may attack normal recipient tissue, producing the exuberant inflammatory response that characterizes this disease. Ocular involvement is most commonly associated with the chronic, rather than the acute, form of the disease. Ocular involvement is estimated to occur in up to 90% of patients who develop the condition.23-25 Severe keratoconjunctivitis sicca is the most common ocular manifestation of the disease; inflammatory conjunctival disease, meibomian gland dysfunction, and lacrimal gland stasis all contribute to decreased tear volume and tear break-up time, development of persistent epithelial defects, or even corneal perforation. Eyelid margins may become keratinized (Figure 1), which further increases the...
likelihood of corneal compromise and extreme discomfort. Use of scleral lenses in the management of GVHD has been reported by several authors. Scleral lenses are also included in descriptions of general management strategies for the condition. The inclusion of scleral lens therapy in these clinical overviews suggests a broadening recognition of the benefits scleral lenses can provide.

STEVENS JOHNSON SYNDROME AND TOXIC EPIDERMAL NECROLYSIS

Stevens Johnson Syndrome (SJS) and toxic epidermal necrolysis (TEN) are severe mucocutaneous reactions, usually to medications, characterized by extensive necrosis and detachment of the epidermis. The two conditions are differentiated on the basis of severity and percentage of the body surface involved; with SJS, less of the body surface is affected than with TEN. Both conditions typically affect mucous membranes, including ocular mucosa. Incidence is relatively low (two to seven cases per million people per year), but overall mortality rate is approximately 30%. In the acute phase of the disease, which generally lasts from 8 to 12 days, the most common ocular manifestation is severe conjunctivitis. Corneal ulceration is not uncommon, and anterior or posterior uveitis may be present. Long-term ocular complications include trichiasis, corneal neovascularization, symblepharon, and corneal scarring. These complications may occur months or even years after the acute phase of the disease, and can threaten vision if not adequately managed. Several authors have described the use of scleral lenses in the management of SJS/TEN and have reported improvements in vision-related function and quality of life with scleral lens therapy. General guidelines for management of SJS/TEN include reference to scleral lenses, along with autologous serum drops, mucous membrane grafting, conjunctival replacement surgery, limbal stem cell transplantation, and keratoprosthesis.

EXPOSURE OR NEUROTROPHIC KERATOPATHY

Although exposure and neurotrophic keratopathy do not share a common pathophysiology, both are associated with chronic, nonhealing epithelial defects. Exposure keratopathy is caused by an abnormality in eyelid function or structure, which either decreases the ability to blink or renders the blink ineffective in distributing tears over the ocular surface. Neurotrophic keratopathy is characterized by impaired corneal sensation, resulting from traumatic insult to the trigeminal nerve. Specific causes of neurotrophic keratopathy include viral infections, surgical trauma, congenital or acquired disorders of the trigeminal nerve, systemic conditions (diabetes, multiple sclerosis), toxic insult to the cornea, or even contact lens wear. Scleral lens therapy has been reported to promote resolution of epithelial defects in such cases. Refractory persistent corneal epithelial defects may require continuous wear until complete re-epithelialization is achieved. Ciralisky and colleagues described a standardized regimen for this protocol in 2014. Certainly, continuous wear of a contact lens in the presence of a corneal epithelial defect will require careful follow-up, and should be considered only if all other options have been exhausted. A recent overview of management options for combined exposure and neurotrophic keratopathy included a brief discussion of scleral lenses.

KERATOCONJUNCTIVITIS SICCA ASSOCIATED WITH CHRONIC INFLAMMATORY AUTOIMMUNE DISEASE

Chronic inflammatory autoimmune disorders include conditions such as Sjögren’s syndrome, rheumatoid arthritis, and systemic lupus erythematosus. Sometimes referred to as connective tissue diseases, these conditions can be associated with severe ocular inflammation (e.g., scleritis, episcleritis, and peripheral ulcerative keratitis). Lacrimal gland function can be impaired in these patients. Decreased tear production causes classic dry eye symptoms such as burning, gritty sensation, ocular fatigue, blurred vision, or photophobia. Severe cases may lead to non-infectious keratitis, corneal neovascularization, or corneal scarring. The goals of treatment are to minimize patient symptoms and preserve the integrity of the ocular surface; evidence-based guidelines on management of keratoconjunctivitis sicca have been published. Recommendations for therapeutic intervention become more aggressive as symptom severity or ocular surface compromise increases. Although scleral lenses are not generally considered first-line therapy for keratoconjunctivitis associated with systemic inflammatory disease, success has been reported with scleral lens therapy in these patients.

CHALLENGES OF SCLERAL LENS THERAPY FOR OCULAR SURFACE DISEASE

In all of the conditions described above, scleral lenses are used in the management of ocular surface disease that is associated with systemic disease. Because of this, changes in severity of ocular surface disease may suggest that a change in systemic management would be prudent. Changes in overall management may also require altering the strategy...
for ocular therapy. Exceptional patient care will require communication and cooperation with specialists in a wide variety of disciplines that extend well beyond eye care. While coordination of care may be relatively easy to achieve within a multidisciplinary practice, eyecare providers who work outside of such settings may need to invest time and energy into communication with other healthcare professionals who are involved in the care of their patients.

Precise evidence-based placement of scleral lenses within an overall management strategy has yet to be defined. A number of factors need to be taken into consideration prior to the initiation of scleral lens therapy. These include current therapy, disease severity or progression, patient characteristics (such as anticipated ability and willingness to handle lenses), and patient preferences. Most would consider it reasonable to suggest environmental modifications, such as increasing ambient humidity and avoidance of tobacco products, prior to initiation of scleral lens wear. Patients who are able to maintain reasonable comfort and good ocular surface integrity with topical therapy or punctal plugs may not need to consider scleral lens wear. However, if these basic therapeutic interventions are insufficient to maintain the ocular surface, additional options (including scleral lenses) must be considered. At this point, a detailed conversation with the patient is required to discuss risks, benefits, and burden of care associated with further intervention. Patients should understand that additional intervention is additive. For example, use of scleral lenses is unlikely to eliminate the need for less aggressive interventions, such as environmental modifications, the use of artificial tears, or other topical treatments, but will provide additional ocular surface protection or symptomatic relief.

Surface deposits are common in patients who wear scleral lenses for management of OSD (Figure 2). The lenses are fabricated from highly oxygen-permeable materials, which are typically relatively hydrophobic and therefore predisposed to surface deposits. Additionally, poor tear quality and compromised blink function also increase the likelihood of surface deposits. Although we do not yet have a single, unified solution to this vexing issue, several modifications may help to alleviate the problem.

- Aggressive management of existing meibomian gland dysfunction prior to initiation of lens wear can be helpful. Mechanical therapy (warm compresses, eyelid scrubs), omega-3 nutritional supplements, oral doxycycline, or topical anti-inflammatory agents could be considered.
- Alteration in overnight therapy may be indicated. If a patient is accustomed to using an ointment overnight, switching to a water-based product may reduce surface deposits on the lens in the morning. If the patient requires more surface protection than a water-based product can provide, the use of an eye mask in combination with lubricant drops may provide a reasonable alternative to ointment. Alternatively, rinsing the ocular surface with non-preserved saline upon waking may remove residual ointment or gel from the tear film prior to lens application.
- Changing the lens material may reduce surface deposits for some patients.
- Plasma treatment is highly recommended for all scleral lenses. Newer surface treatments, such as Hydra-PEG, are promising.
- Modifications in patient cleaning and care regimens may be helpful. An alcohol-based daily cleaner is recommended for all patients. However, storage or disinfection solutions may vary. Many patients do well with non-preserved products (such as hydrogen peroxide disinfection systems). However, others experience fewer surface deposits if the lens is stored in conditioning solution or even in a multi-purpose solution designed for use with hydrogel lenses. If a preserved product is used for disinfection or storage, rinsing the lens prior to application is recommended to reduce the likelihood of entrapment of preservatives in the post-lens fluid reservoir.
- Use of nonpreserved rewetting drops over the lens during wear can be suggested.
- It may be helpful to periodically clean the front surface of the lens with a moistened cotton-tipped swab or plunger during wear. Midday lens removal for thorough cleaning with an alcohol-based surface cleaner may be necessary.
- Daytime moisture release eyewear over scleral lenses may add benefit for some patients with ocular surface disease.

CONCLUSION

Improvements in vision, ocular comfort, and ocular surface integrity can be achieved with scleral lens therapy in patients with severe ocular surface disease. Hopefully, future studies that establish the efficacy of scleral lenses in the management of these conditions will lead to an increased number of patients who can experience improved vision, comfort, and quality of life with scleral lens wear.
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As early as 1800, the precursors of scleral lenses — blown glass shells — were described.1-3 Fick and Kalt1,2 explored the potential for optical correction of corneal irregularity in keratoconus with their original lenses, while Mueller described the use of a blown glass shell to correct significant myopic refractive error.3

Scleral lenses provide a smooth anterior ocular surface and neutralize the irregularity of the ocular surface. Since scleral lenses do not rest on the cornea, and are supported by the conjunctival tissue overlying the sclera, there are several potential benefits. Improved lens centration and stability may be attained with scleral lenses compared to corneal lenses on eyes with highly irregular corneas. Lens awareness is reduced, lenses are more comfortable, and lens adaptation time is reduced since scleral lenses do not come into contact with the highly innervated cornea.

When a patient presents with keratoconus, pellucid marginal degeneration, post-refractive surgery, post-corneal transplant or corneal scarring, what do you prescribe? Patients with poor vision due to irregular corneal surfaces and irregular astigmatism may present a challenge for eye-care practitioners. For patients who have irregular corneal curvature, corneal gas-permeable (GP) lenses are a great option that can provide excellent visual acuity. However, if lens centration, lens stability, or lens adaptation are insufficient with GP lenses, scleral lenses are an option. Many practitioners are utilizing scleral lenses as the ideal mode of correction for patients with corneal irregularity.

Epidemiological studies generally report prevalence of keratoconus (KC) to be 1 in 2,0004,5 with variability dependent on geographic location (some areas report as high as 1 in 400), ethnicity (more common in African-Americans and Latinos) and criteria for diagnosis. In addition, the number of patients who have had refractive surgery (RK, PRK, LASIK, CK or others) is increasing yearly. By 2013, 19 million people in the US had undergone LASIK6 and about 600,000 new procedures are performed each year. The percentage of patients with complications or poor outcomes is small (0.5 -1.0%).7 That said, providing comfort and good vision for patients who experienced complications or poor outcomes from refractive surgery can be difficult. Extensive publications have documented the indications and benefits of scleral lenses including visual improvement for conditions with irregular astigmatism, ocular surface protection and restoration, trauma, persistent epithelial defects, amongst others.8 Here, I will review how to prescribe and fit scleral lenses for irregular corneas.

WHY FIT SCLERAL LENSES

Newer scleral lens designs provide excellent visual acuity due to the GP optics.9 Lenses can be customized with front toric or multifocal designs to correct for some of the most challenging visual demands. In addition, scleral lenses provide excellent comfort. If you have not tried them yourself, you should. Most people describe the feeling of a properly fit lens as being more comfortable than their soft lenses. Due to their size and resting position, scleral lenses will not dislodge with quick eye movements, and airborne particles rarely get under the lenses. Finally, scleral lenses help maintain a healthy ocular surface.10 Since scleral lenses vault the cornea and land on the scleral conjunctiva, they maintain a layer of tears (post-lens tear reservoir) to continually bathe and provide moisture to the cornea.

CANDIDATES

Ideal candidates include any patient with an irregular corneal surface. As mentioned above, patients with keratoconus, pellucid marginal degeneration, post-penetrating keratoplasty, corneal scarring, irregularities following refractive surgery, or ocular surface disorders are most appreciative of the benefits of scleral lenses. For some patients, fitting scleral lenses may eliminate or delay the need for corneal transplantation.11 In addition, patients with ocular surface disease report less dryness when wearing scleral lenses. In cases of ocular surface disease or persistent epithelial defects, scleral lens wear can facilitate healing and long term corneal health.10 Finally, scleral lenses are a great option...
for patients with “normal” corneas and high prescriptions (myopia, hyperopia, and/or astigmatism). Presbyopia correction can even be employed.

**INITIAL LENS SELECTION**

The goal of scleral lens fitting is to vault over the entire cornea by fitting a lens that has a sagittal depth greater than the sagittal height of the eye. Therefore, one of the most important measurements becomes the corneal diameter or horizontal visible iris diameter (HVID). Each of the various scleral lens types or designs has a different approach on how far beyond the limbus the lens should land. However, each lens should land gently on the sclera without corneal or limbal contact. To achieve corneal clearance, the recommended overall lens diameter is at least 2 mm larger than the corneal diameter. On an average cornea of 11.8 mm, a good starting diameter is 15.8 (11.8 + 2 mm on each side = 15.8 mm) or larger. With experience and evaluation of each individual ocular condition, a practitioner may prefer to start with a larger or smaller lens diameter. It is necessary that the sagittal depth of the initial lens selected be greater than the sagittal height of the cornea. The elevation of an individual cornea may be estimated using topographical elevation data, anterior segment OCT imaging, HVID, elevation of corneal protrusion from a side view, or simply by judging the severity of the condition (advanced, moderate, or early stage). In general, a larger lens diameter is required with more significant corneal irregularity.

**INITIAL LENS EVALUATION**

After applying the lens with application solution and fluorescein in the bowl of the lens, verify that “application bubbles” are not present. This can be done with a handheld blue light penlight or at the slit lamp, utilizing a cobalt blue filter with low magnification. After confirmation that bubbles are not present, allow the lens to settle for 15 to 20 minutes. Next, evaluate three major fitting characteristics.

- **Amount of apical (central) clearance - thickness of the tear film (post-lens tear thickness) between the cornea and the lens:** This is done with an optic section of white light using a slit lamp comparing the known lens thickness to tear thickness (Figures 1 and 2). About 50% of the total settling occurs within the first 30 minutes of wear. Central apical clearance also may be evaluated by comparing the post lens tear thickness to the thickness of the cornea. Keep in mind that patients with corneal ectasia may have thinner than average corneal thickness.

- **Limbal Clearance:** Using a slit beam with white light, evaluate the post-lens tear thickness at the limbus. This may be difficult to quantify, however limbal clearance is critical to ensure that the lens does not bear on limbal stem cells.

- **Landing/edge profile:** An ideal landing is a soft parallel landing on the scleral conjunctiva. There should be no impingement of conjunctival vessels, compression into the sclera nor edge standoff. It is critical to carefully evaluate the landing in all quadrants.

If there are any areas of lens bearing on the cornea, select another diagnostic lens with more sagittal depth. Once central corneal clearance is observed, evaluate the limbal clearance and scleral landing. Each lens design has step-wise changes that can be made to alter each of these areas to ensure an ideal fit of the lens centrally, over the limbus and scleral landing zone. Studies have shown that patients can be successful with various amounts of central clearance.

In general, a well-fit scleral lens will have little or no movement. In addition, the larger the diameter of the scleral lens, the greater the chance of lens decentration (most commonly temporal and/or inferior). Significant decentration can reduce visual acuity, particularly when prescribing multifocal scleral lenses. After all fitting characteristics have been critically evaluated, perform a careful spherocylindrical over-refraction to provide the best possible vision correction with the selected lens.

**DESIGN OPTIONS**

Achieving ideal fitting characteristics of scleral lenses often can be accomplished using standard designs. More complex designs are sometimes required. These include: toric peripheral curves to align all meridians of landing with the toricity of the sclera, reverse curves to bring the lens surface closer to the cornea in cases where there are rapid...
changes in shape, front toric designs to correct for residual astigmatism and multifocal designs (near-center, distance-center, or aspheric) to provide for presbyopic correction.

INITIAL LENS ORDER
With the diagnostic fitting information, laboratory consultants can help design the initial lens. Reach them by phone, email, or a web-based system. Be prepared to provide very specific information about the diagnostic fitting evaluation. Information includes the best estimation of the amount of central tear thickness in microns, the amount of limbal clearance, observation of edge-fitting characteristics in all quadrants, sphero-cylindrical over-refraction, and any additional specifications or lens parameters.

APPLICATION, REMOVAL, AND LENS CARE
During the fitting process and when applying a lens, special techniques must be employed to assure that bubbles are not present between the lens and the eye. Although some cases can be quite challenging, tools including instructional videos, one-on-one instruction, and practice can simplify this process until it becomes routine. During scleral lens application, as the lens is brought upward toward the eye, it is critical that little or no loss of preservative-free saline solution occurs in the bowl of the lens. A lens holder is recommended for application while a separate contact lens removal device is used to remove the lens. There are very specific instructions about solutions for application, disinfection, and for use in the eye during lens wear. These instructions should be reviewed one-on-one with the patient during the lens dispense visit. The patient should also be provided with written instructions. All instructions should be reviewed and verified at each follow-up visit. Noncompliance with lens care procedures and products can create problems, even with an ideal fit.

FOLLOW-UP
As with any contact lens patient, evaluating the patient's comfort, vision, comfortable wearing time, and eye health is imperative. Although complications are rare, careful evaluation during follow-up visits may help to identify potential problems early. The first follow-up visit with scleral lens wearers should be done at 1 or 2 weeks with lenses worn for more than 3 hours that day. Patients usually describe scleral lenses as comfortable, and report very little awareness of the lens. When patients report awareness, scleral asymmetry, edge contour, and the relationship of the peripheral landing area to the sclera are the most common reasons for awareness.14,15 To obtain the best-corrected visual acuity, perform a sphero-cylindrical over-refraction. At the slit lamp, evaluate corneal clearance, anterior and posterior lens surface quality (wetting, deposits, fogging), limbal injection, or any areas of conjunctival/scleral vessel engorgement. On some eyes more than others, “lens settling” or a tight lens may occur. To alleviate this issue, modifications to consider are reduced sagittal depth and/or looser lens peripheries. If evaluating a scleral lens too quickly, there may be an inaccurate over-refraction and lens fit assessment. Again, review care and handling with scleral wearers at every visit.

TROUBLESHOOTING
In combination with clinical observations and the expert advice of laboratory consultants, issues of lens awareness, redness, or inadequate vision usually can be solved with minor lens adjustments. Increased experience using various designs or brands is helpful to promptly make specific changes to correct complications that may occur.

LEARNING TO FIT SCLERAL LENSES
There are numerous resources to help learn the necessary skills and gain confidence in fitting scleral lenses. The Scleral Lens Education Society (sclerallens.org) and GP Lens Institute (gpli.info) websites offer valuable information. In addition, wet labs and fitting workshops are available at national/regional specialty contact lens meetings to learn scleral skills. Also, scleral manufacturers hold dedicated webinars and workshops to gain experience with specific lens designs.

GRATIFYING RESULTS
Overall, fitting scleral lenses for patients with irregular corneas can be very gratifying for both patients and practitioners. Irregular cornea patients who have changed from corneal GP lenses to scleral lenses report improved comfort, longer wearing time, and better visual acuity.19 Clinically, patients do not report getting “something under my lens” nor any reports of lenses dislodging. What’s more, visual-related quality of life studies show higher scores for patients wearing scleral lenses compared to their previous mode of correction.19

For the practitioner, it is rewarding to see and hear patients describe how much you have helped them see more clearly and improve their quality of life. Also, because scleral lenses are specialty lenses, they can generate higher profits from higher fitting fees and enthusiastic word-of-mouth referrals for other specialty patients. If you choose not to fit scleral lenses, consider referring appropriate patients to a colleague who does.

For references, please visit www.clspectrum.com/references and click on document #SCLERAL2016.

Table 1. Scleral Lens Central Tear Film Thickness (microns)13,18

<table>
<thead>
<tr>
<th>Lens Diameter</th>
<th>Ideal Initial Central Clearance (20-30 minutes)</th>
<th>Ideal End of Day Clearance (8+ hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.0-15.0</td>
<td>200-250</td>
<td>100-125</td>
</tr>
<tr>
<td>15.1-16.9</td>
<td>250-300</td>
<td>150-200</td>
</tr>
<tr>
<td>17.0-18.5</td>
<td>300-350</td>
<td>200-250</td>
</tr>
<tr>
<td>18.6 or greater</td>
<td>350-400</td>
<td>250-300</td>
</tr>
</tbody>
</table>
The ProLOOK scleral contact lens design features:

- A unique controlled flexure allows it to be easily customized to your patients needs
- The combination of radii in the landing curves maximize tear exchange
- Central lens thickness over the cornea may be reduced without changing the thickness and performance of the lens, allowing it to be independently adjustable
- Proprietary Essilor CSS fitting system makes fitting this lens simple and easy

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to place your ProLOOK scleral lens order and be on your way to receiving your complimentary fit set.

Five patients must be fit with ProLOOK lenses within 90 days to receive complimentary fit set. Returns and exchanges excluded from promotional offer. Offer valid until December 31, 2016.

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It is well established that scleral lenses are advantageous for protecting the ocular surface and improving visual acuity in cases of irregular astigmatism. As awareness of scleral lenses becomes widespread, the use of scleral lenses continue to grow. However, because the handling and care of large-diameter scleral lens designs is different compared with corneal gas permeable lenses or soft contact lenses, scleral lenses pose some unique challenges, including minimal tear exchange and the potential for fogging in the post lens fluid reservoir. In fact, difficulty with scleral lens handling is the primary reason for dropout. Scleral lens dropout rates vary in the literature, but range from about 25% to 49%. Therefore, proper care and handling of scleral lenses is critical to success.

**INSERTION OF SCLERAL LENSES**

Prior to handling scleral lenses, it is important to wash hands with a mild soap, rinse thoroughly, and dry with a lint-free towel. Avoid oils, lotions, hand sanitizers, and soaps with perfumes. Hand cream, makeup, and hair spray may be used after lens application to avoid a residue on the lens.

Insertion of a scleral lens can be challenging due to the large size of the lens compared with the palpebral fissure; it may be difficult to balance the lens on the fingers with manual insertion. A rubber device called a plunger, or scleral cup, is sometimes used to stabilize and prepare the lens for application. There are a few commercially available plungers in ventilated and non-ventilated designs to aid with insertion and removal of scleral lenses. Although both plunger designs can be used, some practitioners prefer one over the other. A vented plunger allows the lens to balance in the cup without inducing suction. The lens could tip or be displaced if the lens is bumped during the application process due to the lack of suction. A non-ventilated plunger maintains lens stability; but gentle squeezing of the plunger is needed when applying the lens. Pinching the plunger at the junction between the cup and the handle will remove the plunger from the scleral lens in the event that the plunger remains on the scleral lens upon insertion.

There are two methods for scleral lens application. The first is the three-finger approach, or the plunger (also known as inserter) method. To begin, have the patient sit or stand and place a clean towel on a flat table. A mirror lying flat on the table is helpful when applying the lens. With the three-finger method, the thumb, index, and middle fingers are used to create a tripod stand for scleral lens application. The lens is filled with sterile, nonpreserved saline solution, the eyelids are held open, and the scleral lens is placed on the eye.

For the second method, the large plunger method, the ventilated and non-ventilated plungers are prepared by wetting the plunger’s surface with one to two drops of sterile, preservative-free saline solution. Next, have the patient squeeze the non-ventilated plunger and hold the outside edge of the lens and place it on the plunger. When released, the lens is tightly secured to the non-ventilated plunger. With the ventilated plunger version, have the patient hold the outside edge of the lens and place it on the plunger. Next, have the patient overfill the bowl of the lens with sterile, preservative-free saline so the saline appears as a convex or round surface above the lens. The lens is held with the dominant hand. Have the patient lean forward, sitting with the chin toward the chest and eyes facing the mirror on the table with the head parallel to the ground. Holding the eyelids wide open with the index finger on the upper eyelid and middle finger or thumb on the lower eyelid of the non-dominant hand, have the patient steadily move the lens closer to the eye. Instruct the patient to look straight down toward the mirror on the table, and then at the plunger or the hole of the plunger while inserting the lens. To visualize the hole, the patient may close the opposite eye, which may impede application. The goal of lens placement is to be perfectly centered over the cornea. If the lens is placed in the lower cul de sac, the lens should be moved superiorly to center the lens.

**Figure 1.** Scleral lenses utilize a post-lens fluid-filled reservoir that allows the cornea to be submerged in an artificial pool of preservative-free saline solution. Shown, a scleral lens prior to insertion on a large plunger filled with saline and sodium fluorescein.

**Figure 2.** Removal of scleral lens with small plunger on the periphery of the lens.
As the solution touches the eye, the lens is inserted gently. Here again, patients may squeeze their eyes and pull back once they feel the fluid sensation when the lens approaches the eye. The eyelids are released when the lens is on the eye. If using the ventilated plunger, the plunger is removed from the lens gently; if using the non-ventilated plunger, the plunger is gently squeezed to release suction and the lens. The plunger should be cleaned with alcohol or peroxide after each use and allowed to air dry.

After insertion, the patient should use the mirror to inspect the eye for air bubbles that can cause discomfort and decrease vision if the air bubble is in front of the pupil. An air bubble creates a dry area underneath the lens and can cause corneal desiccation through time. Air bubbles may appear upon insertion if the head is pulled back and is not parallel to the ground, causing the lens to tilt upon insertion and allowing air to be trapped between the solution and the eyeball. If an air bubble is present, the lens should be removed and reinserted. To avoid air bubbles, use one to two drops of a thicker, more viscous non-preserved artificial tear, such as carboxymethylcellulose sodium solution, combined with a preservative-free saline solution to fill the bowl of the scleral lens.

**SCLERAL LENS REMOVAL**

Plungers can also be helpful for lens removal. Generally speaking, large plungers are used for insertion and small plungers are used for removal.

A drop of preservative-free saline or artificial tears is instilled in the eye to loosen the lens prior to removal. With the manual two-finger method, the patient first looks up, and pressure is applied to the middle of the lower eyelid below the lashes. The eyelid is manipulated underneath the inferior edge of the lens. Pressure is then applied to the globe, and the lens is lifted. Then, the lower eyelid and finger are used together to nudge the lower edge of the lens off the eye, and the lens is removed. Have the patient stabilize and anchor the upper edge of the lens with the upper lid.

With the small plunger method, have the patient sit in a chair or stand up and place a clean towel on a flat table. Again, placing a mirror on the table can be helpful during lens removal. Have the patient wet the plunger’s surface with one to two drops of sterile, preservative-free saline solution. Next, have the patient look into the mirror. While holding the eye open, the patient should apply the plunger to the lens in the peripheral inferior or superior quadrant by the limbus. The lens is then removed by releasing suction of the lens on the eye with the plunger.

Using the eyelid, press into the globe adjacent to the lens edge where the plunger will be applied to the lens. This pressure may be needed to break the seal of the lens and allow for a bubble under the lens to loosen the lens prior to removal. As the lens is being removed, patients should be cautious not to scrape the edge of the lens across the cornea to avoid causing a corneal abrasion. If the plunger is on the center of the lens, pinch the base of the plunger to remove it from the lens and re-apply the plunger in the peripheral location of the lens. The patient should hold the outside edge of the lens while squeezing the base of the plunger to remove it from the lens. After removal, disinfect and store the lenses. After each use, the plunger should be cleaned with alcohol or peroxide and allowed to air dry.

Cleaning the plunger is critical, as an old plunger can become cracked, may leave residue on the lens surface, and may not provide good suction on the scleral lens. It is beneficial for the patient to have plungers in multiple locations (home, work, school, and so on). Plungers should be replaced every 3 to 6 months, or sooner if the edges become rough, uneven, or if suction is insufficient. Plungers are not readily obtainable at the local pharmacy and should be stocked in-office. Online resources for plungers include dryeyeshop.com, myeyesupply.com, and Amazon.com, among others.

The Scleral Lens Education Society website is a great resource for practitioners and patients. In addition to a how-to video and a downloadable slide presentation, the site provides useful information on how to properly insert and remove scleral lenses, as well as other tips and tricks.

**ADDITIONAL TIPS FOR SCLERAL LENS HANDLING**

Some patients may face unique challenges with handling. For example, older patients, aphakic patients, patients with high refractive error or rheumatoid arthritis, or patients who have dexterity issues as a result of arthritis or missing digits may need extra assistance. If a patient is struggling with application and removal, a family member or friend can be trained to insert and remove the lenses.

Additional tools may be used to increase success with scleral lens handling. For example, inserters with accompanying stands are available to help hold the plunger and lens in place prior to application. This is helpful for patients who have unsteady hands, missing digits, or for those who need both hands to hold their eyelids open.

Another helpful tool is a lens insertion ring, which is placed on the finger like a ring and has a base for scleral lens application. This design provides stability, allowing patients to apply scleral devices with one finger.

Other options are a sterile orthodontic ring or a #8 O-ring from a hardware store. O-ring dimensions are 3/8” x 9/16” x 3/32”. The scleral lens rests on the O-ring on a patient’s finger, which can allow for stable application.

**A LESSON WORTH REPEATING**

Proper care and handling of scleral lenses should not be a one-time discussion. At every visit, care and handling should be reviewed. In addition, patients should be given contact information in case of an after-hours emergency. No matter how well a scleral lens is fit, patients need to understand proper application and removal to help ensure a successful scleral lens experience.

For references, please visit www.clspectrum.com/references and click on document #SCLERAL2016.
Scleral lenses are essential in a specialty contact lens practice. However, a standard rotationally symmetric scleral lens with spherical optics may not consistently provide an optimal outcome for vision, comfort, and corneal integrity. Understanding advanced modifications can mitigate some of these challenges. Often, patient complaints prompt the practitioner to incorporate changes to the design. Complaints may arise from residual astigmatism, front surface debris, reservoir debris, or corneal edema. Lastly, understanding ocular physiology and contraindications to scleral lens fitting can avoid unnecessary complications.

FRONT SURFACE TORICITY AND TORIC PERIPHERIES

Scleral lenses have the same optical mechanism for correcting corneal astigmatism and masking irregular astigmatism as rigid corneal gas permeable lenses. However, sometimes there are other residual sources of refractive error including lenticular astigmatism, higher order aberrations, lens flexure, and lens warpage.

When front surface toricity is employed, it may be used to correct residual lenticular astigmatism. However, a spherocylindrical over-refraction does not necessarily require that the astigmatism is lenticular. Just as a corneal rigid gas permeable lens can flex, a scleral lens may flex as well. Flexure has been well documented in the literature for rigid corneal gas permeable lenses. An over-topography or over-keratometry can differentiate residual astigmatism from flexure. Any astigmatism detected with either topography or keratometry could indicate flexure if the diagnostic lens base curve is spherical. Flexure in rigid corneal gas permeable lenses can occur when the lens bends over a toric surface. Similarly, if the scleral surface exhibits toricity, the misalignment of the scleral lens landing zone and sclera may cause a similar bend to the lens that can induce topographical changes of the scleral lens surface that can be detected with topography and keratometry. To address lens flexure, either the center thickness can be increased or toric peripheries can be incorporated into the landing zone to reduce or eliminate this bending effect. A lens exhibiting flexure on the eye will return to normal shape parameters after removal. Conversely, with lens warpage, the lens will not return to original parameters after removal. This can be verified with a radiuscope and sometimes lensometry.

If the lens is neither flexing nor warped, then the spherocylindrical over-refraction can be applied to the scleral lens using front surface toricity. Typically, if the lens periphery is not toric, stabilization is employed by either prism ballasting or double slab off prism to ensure that front surface toricity is properly aligned. Lenses with front surface toricity have markings similar to soft toric lenses. Always be sure to document the rotation of the scleral lenses. LARS (left add, right subtract) methodology can be applied.

When applying front surface toricity to a lens that requires toric peripheries in the landing zone, it may require multiple steps. First, the amount of toricity of the landing zone and the orientation need to be determined. The landing zone of each meridian is determined independently of one another. If there is compression or impingement along one meridian, the landing zone must be further flattened relative to the periphery of the diagnostic lens used. Conversely, if edge lift is present, the landing zone must be steepened. A lens with toric peripheries will have two different landing zone profiles, which can be in a variety of combinations (flat/
Steep, flat/standard, standard/steep, flat/flatter, steep/steeper). Informing the laboratory consultant that toric peripheries are required is insufficient; the amount of flattening or steepening must be communicated to the consultant to ensure an optimal outcome. Once the toric peripheries are ordered, consider ordering the spherical equivalent of the power for the first lens. This is because the toric landing zone axes may not align with the optical axes. The toric landing zone axis will be determined when the lens with toric peripheries is applied to the eye. At this point, the over-refraction can be incorporated to the front surface and LARS can be used to compensate the discrepancy of the axes. If the diagnostic set already has toric peripheries, but the landing zone is not optimal, the axis of scleral toricity can still be determined. Often, one of the axes (typically the flat) is labeled on the diagnostic lenses with a laser marking (Figure 1). The lens peripheries must be ordered to optimize alignment, and front surface toricity can be ordered in the first lens as long as the axis of one of the meridians is measured. It is very important to document the rotation or orientation of scleral lens toric peripheries to optimize the optical toricity.

FOGGING
Scleral lens “fogging” is a challenge for practitioners but even more so for patients. In most cases, the lens can be refreshed by removing, cleaning, and refilling with fresh application solution to alleviate the complaint; however, this can be inconvenient and time consuming for the patient. A complaint of “fogging” may also stem from corneal edema, in which case, refreshing the lens will not alleviate the fogging complaint.

FRONT SURFACE FOGGING
Front surface fogging is managed differently from back surface fogging. Figure 2 demonstrates front surface depositions. When treating aqueous deficient dry eye disease with scleral lenses, mucins and oils make up the majority of the tear film. Those substances adhere to the front surface of the lens and the aqueous component of the tear film is insufficient to dilute or rinse away these deposits. Supplemental topical lubricants may help but aren’t always effective. Punctal plugs may be beneficial. Patients can also “squeegee” the lens surface by using a moistened fresh cotton swab or a removal plunger that is soaked with solution (either saline or conditioner) to clean the surface. Patients should be cautioned to use only the edge of the plunger as the squeegee (Figure 3) and not apply the plunger directly to the surface of the lens, which could inadvertently adhere the plunger to the surface of the lens. Additionally, patients with incomplete blinks and those being treated for exposure keratopathy will also experience a predictable band of deposition on the front surface of the lens. In these patients, plasma-treated lenses are recommended (Figures 4a and 4b).

RESERVOIR FOGGING
The most common problem of scleral lens wear is fogging in the reservoir of vaulted space between the back surface of the lens and the cornea (post lens tear reservoir). Debris continues to accumulate within the reservoir. Walker4,5 reported that samples of reservoir fluid demonstrated no significant change in protein profiles between the clear samples and foggy samples — essentially mucin was not present in either samples. However, there was an increase in a lipid-based substance in the foggy samples. This was further supported by the work of Hemmati and colleagues.6

Practitioners have reported clinical observations of different appearances of the fogging material; however, the material was never confirmed with laboratory studies.7 Figure 5a shows white, opaque particulate matter that floats in the reservoir. Large particles can settle in the bottom of the reservoir and appear similar to a hypopyon. Changing the solution to a non-preserved solution may reduce this phenomenon. In addition, GPC should also be ruled out. Oily semitransparent debris in Figure 5b accumulates in the reservoir and may be lipid-based (again, this has not been studied). Managing any lid disease can be helpful in reducing the oily particles. The debris in Figure 5c looks like diluted milk and is often observed in patients with atopic disease. Mast cell stabilizers or low-penetrating steroids may improve this condition (used prior to lens insertion or after lens removal). Furthermore, a combination of these types of debris can occur together.

Using a preservative-free, more viscous artificial tear in the reservoir can act as a liquid gasket, preventing seepage of debris. Some patients prefer to use one to two drops of a more viscous drop and then fill the remainder of the lens bowl with saline. Others prefer a 50:50 ratio or more. However, if the gel...
drop spills over the surface of the lens, it will blur vision. The gel drop can be easily rinsed away with saline.

Incorporating toric peripheral curves can reduce debris intrusion by reducing the path of excessive tear exchange. The more aligned the landing zone, the less likely debris will infiltrate the reservoir. Fluorescein can be applied to the front surface of the scleral lens and the path of exchange can be determined. Tear exchange ensures that the lens is not sealed off completely, but excessive tear exchange can be problematic (Figure 6). Reducing the sagittal clearance can improve peripheral alignment and reduce significant accumulation of debris. Although not a true scleral, fitting the lens with peripheral corneal contact, such as a corneo-scleral lens, can reduce fogging, because debris cannot bypass the limbal contact. The area of corneal contact should be monitored carefully for staining and mechanical insult.

**ENDOTHELIAL CELL COUNT**

Endothelial cell loss is unavoidable in donor corneas after penetrating keratoplasty. Lass and colleagues\(^4\) reported 69% endothelial cell loss 5 years after transplantation. Irregular astigmatism from a corneal transplant is an indication for scleral lens fitting. In these patients, practitioners should obtain an endothelial cell count as a baseline prior to initiating scleral lens fitting. Oxygen delivery should be optimized for endothelial cell health. Enhancing oxygen to the cornea with scleral lenses includes: reducing the sagittal clearance, using high Dk materials, ensuring tear exchange, and, in some cases, minimizing lens thickness. Each corneal transplant is unique in its curvature and tolerance of scleral lenses. A patient with an endothelial cell count of 400 cells/mm\(^2\) may be successful with a scleral lens but a patient with 1300 cells/mm\(^2\) may become edematous and the graft fails. Graft failure\(^5\) is when the transplanted cornea is cloudy and compromises vision for 3 months, whereas graft rejection is inflammatory. Scleral lens wear can exacerbate corneal edema. The patient may experience hazy vision and see rainbows around light sources (Sattler’s veil akin to PMMA wear). The patient may complain of “foggy vision,” but the differentiating factor between edema and debris is that foggy vision will persist after refreshing the lens. If “foggy vision” was due to debris, vision would be clear. Also, debris will not create rainbows around light sources. Scleral lens cessation reverses the edema.

Challenging a corneal transplant with scleral lens wear for 4 to 6 hours before initiating a fitting can aid in determining patient candidacy. The patient should evaluate for rainbows during the wearing time. If there is no evidence of corneal edema after the challenge, the fitting can commence. If the transplant demonstrates epithelial corneal edema, the patient is a poor candidate for a standard scleral lens. Fenestration, however, may be a consideration.

**FENESTRATION**

Fenestrated scleral lenses are not typically utilized, but can be invaluable for a transplant that experiences epithelial edema with scleral lenses. For example, a patient with an endothelial cell count of 745 cells/mm\(^2\) who demonstrated epithelial edema after 4 hours of scleral lens wear was able to wear the lens uninterrupted for 16 hours of wear without edema and 20/15 vision after the lens was remade with a fenestration.\(^10\)

When fenestrating a scleral lens, the sagittal depth needs to be reduced; otherwise, the bubble introduced from the fenestration can fill the entire tear reservoir. The bubble size and location needs to be controlled to prevent extended corneal desiccation and visual interference. Often, the bubbles in fenestrated scleral lenses are mobile and the risk of desiccation is reduced.

**CONTRAINDICATIONS TO SCLERAL LENS FITTING**

Patients who are predisposed to corneal edema may become more edematous with scleral lens wear (Figure 7). In summary, scleral lenses can be used to rehabilitate a variety of corneal conditions. From visual rehabilitation to attenuation of pain, I believe that treatment with scleral lenses can be transformative for patients and may improve their quality of life. Knowledge of advanced fitting techniques can help to improve scleral lens outcomes. ●

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