“Maximizing Safety of Contact Lens Wearers”

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Contact lenses provide millions of people with clear, comfortable vision. Contact lenses can have a profound effect on patients’ lives not only by enhancing their vision, but also by improving cosmesis and increasing versatility. Although contact lenses have
many benefits, it is also important to remember that these lenses are medical devices and should not be prescribed without careful forethought. Pathogens lurk in the dark corners of contact lens cases and hide out under the fingernails of contact lens wearers, waiting for an opportunity to launch an attack on a compromised cornea. It is not always an outside source which puts the contact lens wearer at risk; sometimes it is the contact lens-altered physiology which puts contact lens wearers in harm’s way. The cornea needs oxygen to maintain its natural defenses, and even the lens with the highest oxygen transmissibility compromises the normal amount of oxygen reaching the cornea.

While it may seem that the contact lens wearer has to fend off multiple adversaries, there are many different groups fighting for the safety of contact lens wearers. Contact lens manufacturers are always working to produce develop safer lenses-lenses which provide more oxygen to the cornea and reduce the mechanical effects of lenses. Contact lens representatives educate optometrists about the latest lenses and how lenses can be most effectively utilized. Optometrists have the most critical role in maximizing the safety of contact lens wearers because they have the most contact and greatest influence on patients. Technicians also play an important role in patient education because they often are responsible for educating patients about proper care of contact lenses.

Contact lens manufacturers spend millions each year on research and development to help ensure the safety of the patients who wear their lenses. Most major companies also have websites and pamphlets to help educate patients about
wearing contact lenses safely. The safest contact lens is the one that can most closely imitate the natural conditions of the ocular surface. The lens should provide as much oxygen as possible, be as thin as possible, and disrupt the tear film as little as possible.¹ The commercial introduction of silicone hydrogel lenses in 1998 was a breakthrough in contact lens development.² Silicone hydrogel lenses allow the greatest oxygen transmissibility coupled with excellent comfort and the possibility of continuous wear. Some patients have the tendency to wear their lenses continuously regardless of the material or recommended wearing schedules, so the development of lenses actually designed for continuous wear greatly increases the safety of these patients. Daily disposable lenses offer a hassle-free care regimen and allow a new lens to be placed on the eye each day, minimizing the effect of any deposits which might develop. These lenses nearly eliminate the problem of contact lens contamination. Contact lens companies are even researching how to make the contact lens cases safer. For example, in 2006 Ciba introduced the Pro-Guard lens case infused with silver ions to help reduce lens case contamination and better protect the consumer. The Pro-Guard lens case was shown to reduce case contamination by 40 percent.³⁴ This is just one example of a contact lens company developing new products to help protect patients. Contact lens companies are constantly striving to provide lenses that perform better and have decreased impact on the ocular surface, thereby increasing safety of contact lens wearers.

Contact lens representatives are the link between the newest products with the best safety profiles and eye care providers. Optometrists rely on contact lens
representatives to inform them of the latest developments in contact lens designs. Representatives are extremely knowledgeable about lenses and can provide valuable recommendations about appropriate lenses for patients with specific needs. Fitting a patient in the lens which best fits his/her lifestyle makes contact lens wear safer because the recommended wearing and replacement schedules are more likely to be followed.

Professional optometric and ophthalmological groups are also working diligently to protect the safety of contact lens wearers. Groups such as the American Optometric Association and the American Academy of Optometry provide a multitude of resources for both eye care providers and patients. Professional organizations also encourage research that can develop new guidelines and products which make contact lens wear safer. Continuing education classes and poster sessions offered at meetings of these organizations help educate clinicians about how to provide better patient care, resulting in increased safety for patients. Professional organizations also offer suggestions to groups such as the FDA to make testing of contact lens-related products more effective.

Although manufacturers, representatives, and professional groups all play vital roles, the optometrist is the most critical to maximizing the safety of contact lens wearers. It is the optometrist who determines if the patient is a good candidate, selects the appropriate contact lens, educates the patient regarding contact lens wear, and follows up with the patient to make sure the lens selected is the right one. If the clinician fails to perform any of these duties correctly, complications with contact lens wear are more likely to develop.
Patient selection

Patient selection is the first step in safe and successful contact lens wear. It is important that optometrists recognize conditions that contraindicate contact lens wear to decrease the probability of complications. There are some obvious contraindications to lens wear such as a history of ocular infections, but there are multiple contraindications which are more subtle. The clinician should consider factors such as motivation, medical history, work environment, and ocular health when prescribing contact lenses.

Patients have many different motivations for wearing contact lenses and it is the clinician’s responsibility to determine the validity thereof. Clinicians should avoid prescribing lenses to patients who are not mature enough to handle the responsibility. Patients who have poor hygiene or jobs that require unsanitary conditions should also not be prescribed lenses. Successful contact lens wearers are highly motivated and are willing to weather some minimal inconveniences for the opportunity to have clear vision without wearing spectacles. Good candidates for contact lens wear should have realistic expectations about lens performance, and it is the responsibility of the eye care provider to counsel the patient about reasonable expectations. Patients should be educated about the risks of improper contact lenses before the fitting occurs so he/she can make an educated decision.

Systemic conditions such as diabetes, Sjogren’s syndrome, pregnancy, and thyroid conditions are relative contraindications to contact lens wear.¹ Diabetes can cause neuropathy throughout the body, including the cornea. Neurotrophic keratitis is
a condition which causes dennervation of the cornea, resulting in decreased sensitivity. Diabetes also increases healing time, a dangerous situation if the corneal epithelium is damaged. Sjogren’s syndrome and other collagen vascular disorders such as rheumatoid arthritis may have keratoconjunctivitis sicca which compromises the ocular surface. Adding a contact onto a damaged ocular surface puts the patient at risk for ocular infections. A healthy tear film is also vital for successful contact lens wear. Pregnancy and systemic medications can adversely affect the quality and quantity of tears. Patients with the aforementioned conditions will likely not be satisfied with contact lenses so it is unwise to put their ocular health at risk by prescribing contact lenses.

Environmental factors can easily be overlooked when evaluating the safety of prescribing contact lenses for a patient. Patients who work in outdoors in windy, dusty environments are not ideal contact lens candidates. If the patient has job that makes it difficult to keep his/her hands clean, contact lenses are probably not the best choice for vision correction. Occupations requiring extended working hours such as military positions may not be compatible with contact lens wear. Any environment that prevents adequate hand-washing increases the risk of contact lens complications. Microbes accumulate on the hands and can infiltrate the ocular surface if given a foothold.

A sick ocular surface is no place for a contact lens. Patients who have a history of ocular infections have increased susceptibility to future infections. If the cornea is prone to infections under normal conditions, the addition of a contact lens will only decrease the natural defenses of the cornea. To properly defend itself against invaders and mechanical damage, the cornea needs a healthy tear film and plenty of oxygen.
Unfortunately, a contact lens can alter the tear film and reduce the amount of oxygen available to the cornea. There are many ocular conditions which a clinician should be cognizant of when prescribing contact lenses. Any pathology of the lids, conjunctiva, or cornea has the potential to alter corneal physiology and affect contact lens wear.

A patient with a history of corneal ulcers either has an ocular surface susceptible to ulcer development or is not compliant with the cleaning routine or wearing schedule. Regardless of which of these factors is to blame, it is the optometrist’s responsibility to decide if the patient is capable of safe contact lens wear. Patients with a history of complications from soft lenses can sometimes be successfully fit into gas permeable (GP) lenses which allow greater tear film contact with the corneal surface.\(^1\) The wearing schedule or replacement may be altered so compliance is increased and the possibility of ulcers recurring is reduced.

Both anterior and posterior blepharitis decrease the safety of contact lens wear. Anterior blepharitis is caused by an overgrowth of *Staphylococcus*, the same bacteria which can cause peripheral corneal ulcers. Posterior blepharitis causes a deficiency in the lipid layer of tears, allowing the tears to break up more rapidly than usual. A rapid tear break-up time may not allow the cornea to be fully covered by the tear film, and some areas may be prone to exposure and desiccation. If lid disease is present, it should be treated prior to contact lens wear to avoid the occurrence of complications.\(^5\)

Up to 50% of contact lens wearers experience dry eye symptoms, making them twelve times more likely than emmetropes and five times more likely than spectacle wearers to be symptomatic.\(^6\) Dryness is second only to discomfort as the reason for
discontinuation of contact lens wear, so patients with moderate to severe dry eye syndrome are not good candidates for contact lens wear. Contact lens-related dry eye is correlated with an increased risk of bacterial binding and infection, a finding which clearly illustrates the danger of prescribing lenses to dry eye patients. Many systemic medications can affect aqueous production, inducing an iatrogenic dry eye syndrome and potentially contraindicating lens wear. Antihistamines, especially the first generation drugs, tend to decrease aqueous secretion. Anxiolytics, beta blockers, phenothiazines, anti-cholinergics, and oral contraceptives also can have a negative effect on lacrimation.

Corneal dystrophies such as epithelial basement membrane dystrophy (EBMD) and Fuch’s endothelial dystrophy pose a threat to safe contact lens wear. The endothelium is crucial to maintaining proper hydration of the cornea; if the endothelium is not functioning optimally then the cornea is prone to become edematous. If a contact lens is on such an eye, the situation is intensified. If the clinician decides a patient with a mild corneal dystrophy can be fit with contact lenses, the lens chosen should have the highest oxygen permeability possible and should be worn on a daily wear schedule to minimize the effect of the lens on the ocular surface.

Giant papillary conjunctivitis (GPC) is caused by mechanical irritation to the palpebral conjunctiva. If this condition is present, the eye is already having a negative reaction to a foreign irritant and this makes contact lens wear more risky. Patients with allergies may have difficulty wearing contact lenses for multiple reasons. Allergic conjunctivitis can cause itching, redness and a foreign body sensation—all symptoms
which are likely exacerbated by contact lenses. Oral antihistamines used to treat seasonal allergies can dry out the ocular surface, making contact lenses uncomfortable.

**Lens Selection**

Once a patient has been selected as a good contact lens candidate, prescribing the right lens is the next step in ensuring safe contact lens wear. There are several lens parameters which affect the impact the lens will have on the ocular surface. The oxygen transmissibility \((Dk/t)\) value is one such parameter. Lens diameter, wettability, and material also affect the overall health of the cornea. There are several ideal characteristics for a contact lens material including the following: non-toxic, wettable, resistant to deposits, durable, and aberration-free. Evaluation of the anterior and posterior segments, tear film, adnexa, and corneal curvature by the clinician aids in the lens selection process.

It is very important to know what the patient expects of the contact lenses prescribed and what type of wearing schedule they desire. The clinician should question the patient about his/her work schedule and hobbies to best determine the appropriate wearing schedule. If the clinician does not have a clear idea of how the patient would ideally like to wear the lenses, then a lens with the wrong wearing schedule may be prescribed, opening the door for complications. There are three different Federal Drug Administration (FDA) classifications of wearing schedules: daily wear, extended wear and continuous wear. Daily wear lenses should be removed every night. Extended wear lenses can be worn for a maximum of seven days and six nights before removal. Continuous wear lenses are approved for up to thirty days of constant wear before
removal. It is extremely important that the practitioner evaluate the ocular and systemic health of the patient before prescribing lenses of a certain wearing schedule. Daily wear lenses can safely be prescribed to most contact lens wearers. Removing the lenses at night ensures more oxygen will reach the cornea, and cleaning the lenses nightly removes deposits which can be irritating to the eye. The clinician must be a bit more judicious when prescribing extended wear lenses. Successful daily wear does not necessarily guarantee successful extended wear because there is great variation among patients in corneal response to hypoxia. The patient must have good ocular health with no history of recurrent infections to consider an extended wear schedule. Patients exhibiting hypoxic signs such as corneal edema, neovascularization, or compromised epithelium are not good candidates for extended wear. Only patients who have already had complication-free contact lens wear should be fit into continuous wear lenses. It is somewhat risky to prescribe continuous wear lenses for a new contact lens wearer because it is unknown how his/her cornea will respond to the lens. If a patient has experienced contact lens complications in the past with extended wear, it is obviously unwise to fit them into continuous wear lenses—the lens category most likely to cause complications. An informed consent document explaining the risks of extended/continuous wear should be signed by the patient to help protect the patient and the eye care provider.

Replacement schedule is another factor that should be chosen thoughtfully. The FDA only classifies lenses as disposable or conventional; it does not directly recommend replacement schedules for contact lenses. Disposable products are designed to be used
only one time, while products classified as conventional can be used multiple times. It is actually the contact lens manufacturers who recommend replacement schedules for their products. Manufacturers have the most intimate knowledge of the capabilities of the products they produce and are logically the best party to decide how their product can be used most safely. If one adheres to the replacement schedule proposed by the manufacturer, complications like lens deposits, decreased comfort, and blurred vision may be avoided. If the lens is worn longer than recommended, the ocular surface will eventually be affected to some degree. One of the first signs that a contact lens needs to be replaced is the formation of deposits on the lens. These deposits can be made of protein or lipids and may form on the surface of the lens or within the lens. The deposits may affect the optics of the contact lens if they are severe enough, but it is much more likely that deposits adversely affect comfort. The palpebral conjunctiva may mount an immune or inflammatory response to the deposits, causing conditions such as giant papillary conjunctivitis. As the lens is worn longer than its intended schedule, the lens material itself may begin to break down, making the lens prone to tears. Daily disposable lenses are a great lens choice for patients who are not good candidates for extended wear. Daily disposable lenses allow the patient to experience the comfort of a fresh, deposit-free lens every morning. Free from the hassle of a care system, many patients are pleased with the comfort, safety, and convenience that daily disposable lenses offer.

Choosing the material is another decision which can affect the safety of a contact lens wearer. A single lens cannot have all the desirable characteristics, so a compromise
must be reached. The clinician must determine which specific factors are most important to each individual contact lens wearer. Some of these factors include wettability, oxygen permeability, water content and ionic charge.

Wettability allows the tear film to naturally flow over the surface of the lens. The more uniform the tear film is, the more comfortable the lens will be. If the lens is not wettable, the lens is more prone to deposit formation because the tear film is not stable enough to wash away debris. Wettability is a desirable lens quality for patients with dry eye syndrome. If the tear film is already deficient because of decreased aqueous production or increased evaporation, the tear film needs to adhere to the lens as much as possible.

Oxygen transmission is clearly important in maintaining corneal health of contact lens wearers. It is the lack of oxygen that causes neovascularization, setting up the cornea for additional complications. The oxygen that actually reaches the cornea is determined by two factors, oxygen permeability and lens thickness. Oxygen permeability (Dk) increases logarithmically with water content. Historically, the lenses with the highest water content were also the lenses with the highest Dk values because the amount of oxygen was dependent on the water content of the lens. Unfortunately, lenses with high water content usually have greater center thicknesses (CT) which reduces the oxygen transmission (Dk/t). Coventional hydrogel materials had a maximum Dk of approximately 80 Dk units, but some silicone hydrogel materials such as lotrafilcon A have a Dk of 140. Silicone hydrogel lenses typically have a low water content but a high Dk, a combination that allows these lenses to be worn longer than
conventional hydrogel lenses. The high oxygen transmission of silicone hydrogel lenses makes extended wear a healthy option for a greater number of contact lens wearers.

Lenses are classified into four groups based on ionic charge and water content by the FDA. Since other qualities such as deposit resistance, wettability, and strength depend on water content, it is reasonable to group materials by water content. Group One and Group Three lenses are classified as low-water, meaning they contain less than fifty percent water. Group One lenses tend to be deposit resistant because they are non-ionic in addition to having a low water content. These lenses are good for patients who suffer from protein buildup on lenses. Group Three lenses are more deposit prone than Group One. Groups Two and Four are high water content lenses, with Group Four lenses having both characteristics known to attract protein deposits—high water content and ionic properties. The clinician should prescribe lenses with a knowledge of their FDA classification in mind, so that potential problems can be eliminated before they develop. Specific care systems such as hydrogen peroxide systems may be recommended if the prescribed lenses fall into one of the deposit-prone groups.

Lens selection is the second step in ensuring safe contact lens wear. The clinician is responsible for prescribing the appropriate lenses because the patient does not have the knowledge and experience to know which lens is right for them. Lens selection can prepare the patient up for years of successful contact lens wear.

**Patient education**

Clinicians typically do a good job of selecting patients, and prescribing a lens that provides good comfort and clear vision. The next step, however, is one where clinicians
can easily fall short. Patient education is the step that might be the ultimate
determinant in whether or not the patient will be able to safely wear contact lenses.
Rates of non-compliance with proper care guidelines have been reported to be well over
fifty percent by some studies.\textsuperscript{11-12} There are many reasons the patient may leave the
office ill-prepared to care for contact lenses. Time constraints, practitioner or patient
fatigue, information overload or a lack of instructions may inhibit successful patient
education. The amount of time the patient spends caring for lenses on his/her own
dwarfs the amount of time spent in office, so the patient must feel confident in lens
insertion and removal and the care system.

The first contact lens fitting can be an overwhelming experience for a patient.
First time contact lens wearers have a lot of information to process during the contact
lens fit. They hear information about corneal curvature, spherical power, correction for
astigmatism, and lens material—all before they even know how to put the lens on their
eye. A clinician should keep this potential information overload in mind and prioritize
topics when educating the patient to ensure the most critical information is
emphasized. After the clinician has selected the lens that provides clear vision and a
desirable fitting relationship, the patient should be instructed on the basics of lens
insertion and removal. Ideally this discussion should take place in a quiet, well-lit room
in which the patient feels comfortable. The patient should be provided with an
emergency contact number in case there is an urgent situation, and any questions the
patient may have should be answered. If a patient feels rushed, he/she may feel
uncertain about how to care for the lenses and this creates a dangerous situation. The
more different modes information can be presented in, the safer the contact lens wearer will be. One-on-one instruction with an experienced staff member, video instruction and written instruction are all effective ways of communicating with the patient. Written instructions are mandatory because concrete step-by-step instructions can clear up any misunderstandings the patient may have forgotten to clarify before leaving the office.

The introduction of cosmetic contacts and companies that sell contact lenses online has affected patients’ perception of lenses. Lenses are much easier to get than ever before, so it should be stressed to the patient that lenses cannot be legally sold over-the-counter. Federal Trade Commission regulations require the optometrist to provide the patient a copy of his/her prescription when the contact lens fit is complete, but optometrists should give the patient additional information to protect the consumer. The topic of ordering lenses over the internet should be discussed with patients so they can be educated consumers if they choose not to purchase their lenses through their eye care providers. Patients should not accept lens substitutions offered by the company unless the clinician approves. Substituting one lens for another may seem rather innocuous to the patient, so the optometrist should explain the variations between brands. Lenses vary in characteristics such as oxygen transmissibility, fit, and water content—all factors which can affect whether the lens can be safely worn. Patients should be encouraged to have annual eye exams to assess the health of their eyes, regardless of where they purchase their lenses.
Some of the possible complications of contact lens wear should be addressed during the patient education phase of the exam. A basic one- or two-line explanation of some of the most common complications can help the patient understand the importance of disinfecting the lenses and adhering to the prescribed wearing and replacement schedule. Corneal ulcers, GPC, and keratitis are relevant conditions to explain to the patient. If the patient knows the specific problems that can result from contact lens overwear or improper disinfection, he/she is much more likely to be compliant. The eye care provider should discuss symptoms with the patient that should not be ignored. Symptoms such as pain, blurred vision, foreign body sensation, increased redness, discharge, and photophobia can indicate infections or inflammation. If the patient does experience any of these symptoms, they should be instructed to immediately remove the lenses and discontinue lens wear until further instruction. The lenses which were removed can help aid in diagnosis so they should be brought to the office visit, if a visit is required. It is the clinician’s responsibility to make the patient feel comfortable about contacting the office if problems develop. All symptoms should be taken seriously, because patients vary in perception of pain. A throbbing pain described by one patient may be only a minor irritation to another. It is the optometrist whom the patient regards as the expert in contact lenses, so the attitude of the clinician has a powerful influence on the patient. If the optometrist makes it a priority to explain complications and what to do if they occur, the patient will be more apt to act appropriately if problems arise.
Minimizing contact with water when wearing lenses is one simple recommendation that can increase the safety of contact lens wearers. Lenses should be removed during swimming or when soaking in a hot tub to reduce the risk of infections. Tap water is not considered sterile and should never be used to wet lenses for several reasons. The minerals, metallic particles and chlorine in tap water can damage the lens and the ocular surface. Tap water may also contain microorganisms that may cause serious infections such as *Acanthamoeba* keratitis. *Acanthamoeba* is a ubiquitous protozoan which exists in one of two forms, trophozoites or cysts. *Acanthamoeba* infections can be difficult to treat because the cyst form allows the organism to resist treatment. Although such infections are relatively rare, often the patient reports swimming in lenses or use of tap water with lenses. It may seem intuitive to optometrists that saliva is not sterile and should never be used to re-wet lenses, but clinicians should still inform patients of the risks of this behavior.

Thoughtful selection of the lens care system can make a big difference in helping patients experience safe contact lens wear. Other than hand-washing, disinfection of lenses is the most effective way of reducing the presence of microbes. The lens solution has direct contact with the corneal surface, both by being absorbed into the contact lens and by being applied when inserting the lens. The following are several ideal properties of a lens care solution which help increase safety: sterile manufacturing, minimal effect on the ocular tissues, compatibility with lens material and other care products, and a labeled expiration date. Most of the popular systems contain preservatives. If the patient is sensitive to these preservatives, superficial damage to the
cornea may occur. Once the epithelium is damaged, the cornea is more susceptible to invasion by microbes even if the damage is mild.\textsuperscript{17} If the patient has seasonal allergies or is generally atopic, a preservative-free care system is the most appropriate choice. A hydrogen peroxide based care system provides the most complete disinfection and is one of the safest choices for a lens care system. Hydrogen peroxide systems are also exceptional for removing lens deposits. Hiti et al. found that two-step hydrogen peroxide systems have greater amoebicidal effects, and provides the greatest protection against \textit{Acanthamoeba}.\textsuperscript{18} Patients should always be instructed to rub their lenses before rinsing and soaking, regardless of what the solution instructions are. The rubbing action helps to loosen deposits and disrupt the adherence of micro-organisms to the lenses.

Experts generally agree that rubbing is a more effective way of cleaning the lenses than rinsing alone.\textsuperscript{19}

Contact lens solution is relatively expensive, so patients attempt to find ways to make one bottle of lens solution last longer. Sometimes patients just add a small amount of solution to “top off” the lens well instead of emptying the case completely.\textsuperscript{1} Clinicians should anticipate this behavior and make sure the patient understands that this is not a safe way to stretch their solution. Contact lens solution is must remain sterile; therefore, it is unsafe to transfer solution to a smaller bottle such as for travel purposes. The tip of the solution bottle can be contaminated if it touches a surface, so the bottle should always be re-capped after use.\textsuperscript{15} Patients should also be counseled about the use of generic lens solutions. These solutions are not in themselves dangerous, but patients should be aware that the chemical composition of these
solutions can change frequently. Cost, not disfection effectiveness, ultimately dictates the ingredients.

The contact lens case can be the source of potentially vision-threatening complications. Lens cases should be rinsed daily with solution, not tap water, and allowed to air dry. Lens cases should ideally be replaced monthly to prevent build-up of microorganisms. Studies have shown that 77% to 100% of cases become contaminated after one month during daily wear.\textsuperscript{20-21} One study of the cases of asymptomatic cosmetic contact lens wearers found that 81% of cases were contaminated.\textsuperscript{22} In light of this study and several others, Gray et al. recommended scrubbing of lens cases, use of hot water (>70 degrees Celsius) to kill \textit{Acanthamoeba}, and frequent replacement of lens cases.\textsuperscript{22} Some micro-organisms can exist in a dormant cyst stage in the case, so replacement is the most effective way of reducing contamination.\textsuperscript{14} The optometrist should help stress the need for frequent lens case replacement by providing multiple extra lens cases at the lens dispensing. The minimal expense of lens cases is certainly worth the stress and money they may save by preventing contact lens complications.

\textbf{Follow-up visits}

Follow-up visits are the perfect time for the clinician to re-evaluate decisions about patient and lens selection. Patient education should also be reinforced at these visits. If problems are developing in any area, the optometrist can use the follow-up visit to avert any serious complications. Patients should be questioned about lens satisfaction and asked if they have any questions or problems with the lenses. Important topics to address include quality of vision, comfort, wearing time, and lens
cleaning/disinfection. In the first few follow-up visits after the fit, adjustments to the fit or power of the lenses can be made before the final prescription is determined. New contact lens wearers will have a period of adaptation, and follow-up visits during this period allow the eye care provider to reassure the patient and reinforce proper contact lens care. The patient should be instructed to wear the lenses for a few hours prior to the appointment so the clinician can most accurately assess the effect of the lens on the patient’s eye. It is also beneficial to schedule follow-up visits just before the lenses are due for replacement, the time when lenses are the most deposited and most likely to cause complications.\textsuperscript{5} A typical follow-up schedule for a new contact lens wearer is appointments after one day, one week, one month and three months.\textsuperscript{5} Normally contact lens patients should be examined every 6-12 months, but if the patient is at a heightened risk for complication, appointments every 3-4 months may be ideal.\textsuperscript{9} The clinician should always remind patients to discontinue lens wear if they develop a red eye or have any pain associated with lens wear.

There are several tests to perform at evaluation visits that can help prevent complications from developing. Aside from visual acuity and over-refraction, the follow-up appointments should focus on evaluating the fit of the lens and the health of the ocular surface. Keratometry may help determine if any corneal distortion from the lens fit is present or if the lens fits poorly. Biomicroscopy should be performed with and without lenses. The following characteristics can be evaluated with the lenses on: centration, movement, coverage, and lens condition.\textsuperscript{4} The physiological effects of the lens are more easily observed after the lenses have been removed. Microcysts, striae,
and endothelial changes are all indicative of corneal edema, but may only be apparent after the lenses are removed.

**Complications**

Ideally, complications should be prevented from ever developing. Realistically, some patients will have problems and clinicians need to be ready to treat such conditions if and when they develop. Contact lens complications can be divided into two broad categories, infectious and non-infectious. Both types of complications are more prevalent in extended or continuous wear, and typically complications are also more severe. Clinicians must be extremely judicious when allowing patients to wear lenses on an extended wear or continuous wear schedule to safeguard ocular health. Many parts of the eye can be affected by these complications, including the lids, conjunctiva, and all corneal layers.

Non-infectious complications are often the result of mechanical forces or hypoxia. Solution sensitivities are another etiology of non-infectious complications. Mechanical trauma can result from ill-fitting lenses, or debris trapped under the lens. Sensitivity reactions to lens solution can cause diffuse corneal staining, injection, and possibly edema. GPC is another common non-infectious complication. GPC is a type 1 sensitivity reaction which is likely due to contact lens deposits or mechanical irritation of the palpebral conjunctiva. During daily wear, several different substances can accumulate on lenses, causing adverse effects. Lipids, proteins, mucus and inorganic compounds found in the tear film can adhere to the hydrophobic surface of the contact lenses. These deposits can be detrimental because they provide an attachment site for
bacteria. The physical and chemical characteristics of the lens itself can be altered by deposits, potentially decreasing the comfort of the lens and reducing wearing time. It is hypothesized that the quality and function of the tear film is affected negatively by lens deposits. Jelly bumps are a well-known type of deposit. These whitish bumps on the front surface of the lens are likely a mixture of protein, lipids, and calcium. These conglomerations absorb into the lens matrix, so it is not possible to remove the bumps without causing damage to the lens. Proteins in the tear film, including albumin, globulin and lysozyme, can bind to the surface of the lens and resist removal by daily cleaners. The addition of an enzymatic cleaner can help prevent protein build-up, and therefore reduce the likelihood of inflammation. Silicone hydrogel lenses have been shown to accumulate significantly less protein than traditional hydrogels, but conditions caused by deposits such as GPC still commonly occur in this population.

Hypoxia can cause a multitude of problems including microcysts, edema, central corneal clouding, neovascularization and polymegathism. Hypercapnia is also detrimental to the ocular surface and often occurs simultaneously with hypoxia because carbon dioxide transmissibility is directly related to oxygen transmissibility. Mandell and Fatt were the first to find that normal corneas become slightly edematous due to hypoxia during lid closure, but this response is three times greater in continuous contact lens wearers. Hypoxia and hypercapnia induce changes in several corneal layers including the epithelium, the stroma, and the endothelium. Epithelial signs of hypoxia include microcysts, epithelial defects, and neovascularization. The epithelial metabolic rate and corneal sensation are also reduced in contact lens wearers. Stromal
changes as a result of contact lens wear include acidosis, edema and striae. Stromal thinning is a chronic stromal change induced by contact lens related physiological changes. Polymegethism, blebs, and cell density alteration are changes which happen within the endothelium and may alter the efficiency of the endothelial pumps.

Fortunately most non-infectious complications can be eliminated or minimized by refitting the patient into lenses with a better fitting relationship or higher oxygen transmissibility. Temporarily discontinuing lens wear or switching the patient to a hydrogen peroxide-based lens care system can also remedy some complications. Contact lens wear will alter the patient’s corneal physiology, but it is important to assess both the severity and effect of this change on the patient’s ocular health.

GP lens wearers share many of the same non-infectious complications as soft contact lens wearers. There are a few complications which occur more frequently in patients who wear GPs, however. Flexure, warpage, decentration, and poor surface wettability are common complications associated with GPs. Flexure and decentration can be caused by a poor fitting relationship. Warpage is often a result of improper cleaning techniques. Poor initial surface wettability can be the result of the manufacturing process, but acquired wettability problems are often the result of protein film formation. Corneal desiccation, also referred to as “3/9 staining” is a complication often linked to GP lenses. Previous studies found the prevalence of corneal desiccation in GP lens wearers to be between 40 and 90%, but this problem is becoming less common because of new lens materials. Corneal dessication should be carefully monitored so it does not progress into dellen formation or vascularized limbal keratitis.
VLK. VLK is most common in GP extended wear patients and presents as a raised translucent area near the limbus accompanied by vascularization and injection. Generally GP complications can be treated in the same manner as soft lens complications by temporarily discontinuing lens wear or by re-fitting the patient into a more appropriate lens.

Infectious complications pose the greatest threat to contact lens wearers. Microbial keratitis is considered the most severe complication, but fortunately it is also rare. The annual incidence of microbial keratitis is 20 per 10,000 extended wear patients, but only 4 cases per 10,000 daily-wear patients. Fungi, bacteria, and viruses all have the potential to cause microbial keratitis. Patients should be educated about the symptoms of such infections including severe ocular pain, redness, discharge and photophobia. Many less serious fungal, viral and bacterial infections can also develop in contact lens wearers. Fungal infections are rare, although recently there was an increase associated with specific types of lens solution. If a patient develops a viral infection such as herpes simplex or viral conjunctivitis, contact lens wear should be discontinued until the infection resolves. The patient should also be advised to dispose of the lenses they were previously wearing. Among bacterial infections, Pseudomonas aeruginosa, Staphylococcus aureus, and Staphylococcus epidermis are the three most common pathogens associated with contact lens wear. Although the treatment of infectious complications is beyond the scope of this essay, there are a few basic guidelines to help protect contact lens wearers. Contact lens wear should be immediately discontinued in both eyes, and an infectious etiology should be assumed to
protect the vision of the patient. Cultures of the lens and case can be performed to either confirm a suspected infectious etiology or rule out an infectious process.

Frequent follow-ups every 24 hours can reassure the patient and help the eye care provider monitor the condition. If the optometrist feels the patient’s vision is threatened and does not feel comfortable managing the case, a referral to a corneal specialist is appropriate.

Today more patients are able to safely wear contact lenses than ever before due to the collaborative efforts of contact lens companies, professional organizations, and eye care professionals. Any mechanical process or pathogen that damages the cornea poses a threat to the safety of contact lens wearers, but new lens materials and improved designs are making complications less common. Throughout the lens-fitting process, from patient selection to the final follow-up visit, optometrists have the greatest influence on the safety of contact lens wearers. Optometrists are uniquely able to help protect patients by choosing lenses that minimize the possibility of complications. In the future, continued research will help protect patients by giving eye care providers additional information about the etiology and prevention of contact lens-related complications. Greater knowledge about how and why complications develop will allow optometrists to give their patients the best care possible.

References

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