OPTOMETRY: THE PRIMARY EYE CARE PROFESSION

Doctors of optometry are independent primary health care providers who examine, diagnose, treat, and manage diseases and disorders of the visual system, the eye, and associated structures as well as diagnose related systemic conditions.

Optometrists provide more than two-thirds of the primary eye care services in the United States. They are more widely distributed geographically than other eye care providers and are readily accessible for the delivery of eye and vision care services. There are approximately 32,000 full-time equivalent doctors of optometry currently in practice in the United States. Optometrists practice in more than 7,000 communities across the United States, serving as the sole primary eye care provider in more than 4,300 communities.

The mission of the profession of optometry is to fulfill the vision and eye care needs of the public through clinical care, research, and education, all of which enhance the quality of life.
NOTE: Clinicians should not rely on the Clinical Guideline alone for patient care and management. Refer to the listed references and other sources for a more detailed analysis and discussion of research and patient care information. The information in the Guideline is current as of the date of publication. It will be reviewed periodically and revised as needed.
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INTRODUCTION

Optometrists, through their clinical education, training, experience, and broad geographic distribution, have the means to provide primary eye and vision care services for a significant portion of the American public and are often the first health care practitioners to examine and diagnose patients with conjunctivitis.

This Optometric Clinical Practice Guideline for the Care of the Contact Lens Patient describes appropriate examination and treatment procedures for patients wearing contact lenses (CLs). It contains recommendations for timely diagnosis and treatment, and, when needed, referral for consultation with or treatment by another health care provider. This Guideline will assist optometrists in achieving the following goals:

- Identify patients who might benefit from contact lens wear
- Evaluate patients who wear, or who desire to wear, contact lenses
- Maintain and improve the care of patients wearing contact lenses
- Manage complications encountered during contact lens wear
- Inform and educate other health care practitioners as well as the lay public about contact lens care
- Assist in the professional care of patients wearing contact lenses.
I. STATEMENT OF THE PROBLEM

A. History and Epidemiology of the Use of Contact Lenses

The most common reason patients seek ophthalmic care is to optimize visual acuity. Estimates suggest that about 50 percent of the population utilize some form of refractive correction, and the natural history of presbyopia indicates that virtually everyone, who lives long enough, will benefit from optical correction.

Contact lenses (CLs) have been used primarily to neutralize refractive errors for over 100 years, but they have achieved reasonable clinical success only in the last several decades. The original CLs were almost exclusively of large scleral or haptic design, and all were made from glass. Feinbloom made a scleral CL with glass optics and a plastic carrier in the late 1930s, but the first practical plastic (polymethyl methacrylate or PMMA) corneal CL was developed by Tuohy in the late 1940s. Hydrogel CLs were invented by Wichterle in Czechoslovakia in the late 1950s. In the 1970s, after recognition of the role of corneal oxygenation in achieving physiological tolerance, hydrogel CLs with enhanced oxygen transmissibility and rigid gas permeable (RGP) CLs became available. These advances and other improvements in both materials and designs have resulted in CLs that are applicable for most forms of refractive error and are both safe and effective for most patients.

Of the approximately 30 million Americans -- perhaps 75 million people worldwide -- who use CLs, the vast majority (about 80 percent) wear hydrogel CLs. Consumers’ costs for CLs and associated professional care are incurred in addition to other eye care costs (e.g., comprehensive eye examinations, spectacles, sunglasses). The solutions used to care for the eyes and lenses represent additional cost as well.

B. General Considerations

The majority of complications encountered with daily wear CLs are manageable by discontinuing their use. Inconvenience, minor physiological and allergic problems, and interruptions in wear are commonplace. More severe (i.e., vision-threatening) complications are less common and include corneal microbial infection and extreme forms of corneal neovascularization (NV), which can lead to scarring of the cornea in the area of the visual axis. The incidence of corneal microbial infection is about 1 case per 1,000 wearers per year. Extending CL wear through one or more sleep cycles appears to increase both the prevalence and severity of all complications.
II. CARE PROCESS

A. Pre-Fitting Considerations

Many factors help determine whether a patient is a good candidate for CLs. Primary among these is motivation to be a successful CL wearer. Unfortunately, there is no individual test or battery of tests that can predict success in wearing CLs.

1. Indications

Some factors that suggest whether a patient is a good candidate for CL wear involve optical, physiologic, and cosmetic considerations. The following indications should be considered in the evaluation of a patient’s potential for successful CL use. (Table 1)

a. Optical Factors

Contact lenses improve visual function by neutralizing ametropia, or minimizing distortion, especially when the patient suffers from more than a modest spherical refractive error or astigmatism, regular or irregular. Myopic patients benefit from the increased magnification provided by CLs, compared with their spectacle corrections. The reverse is true for both hyperopic and aphakic patients; however, such patients benefit from enhanced fields of vision with CLs. For anisometropic patients, aniseikonia and prismatic effects may be reduced or eliminated with CL wear.

b. Presbyopia

Although many patients with presbyopia wear CLs, presbyopia is not specifically an indication for CL correction. Presbyopic patients may wear distance CLs and use additional reading spectacles of various types to address their presbyopia. Alternatively, presbyopes (especially emerging presbyopes) often successfully use what has been termed “monovision” correction in which one eye wears a CL to correct for

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distance vision and the other wears a CL to correct for near vision. Various bifocal CLs are available in either RGP or hydrogel materials.

c. Therapeutic Potential

Contact lenses have been used to manage both aphakia and binocular vision problems, especially accommodative esotropia and convergence excess. Contact lenses, particularly rigid CLs, can optically smooth an anterior corneal surface made irregular by disease (e.g., keratoconus or corneal microbial infection), trauma, or surgery (e.g., penetrating keratoplasty or ineffective refractive surgery). Hydrogel lenses are used as ophthalmic bandages following corneal trauma or refractive corneal surgery. Rigid CLs also have been used to manage or reduce myopia. Both clear and tinted rigid and soft contact lenses have been used for treatment by occlusion in cases of diplopia and amblyopia.

d. Cosmetic Effect

Correcting ametropia by placing a lens directly on the corneal surface improves cosmesis by eliminating the need for a spectacle frame and often unattractive corrective ophthalmic lenses. Some patients elect to wear colored CLs simply to change the appearance of their eye color. Opaque contact lenses also may be used for their prosthetic effect (e.g., masking an unattractive corneal scar or damaged iris or providing an artificial pupil in the treatment of aniridia).
Table 1
Indications for Prescribing Contact Lenses

<table>
<thead>
<tr>
<th>Cosmetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refractive error: anisometropia, myopia, hyperopia, regular astigmatism</td>
</tr>
<tr>
<td>Prosthetic use</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Therapeutic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myopia management</td>
</tr>
<tr>
<td>Reduction (i.e., orthokeratology)</td>
</tr>
<tr>
<td>Maintenance</td>
</tr>
<tr>
<td>Aphakia</td>
</tr>
<tr>
<td>Keratoconus</td>
</tr>
<tr>
<td>Corneal irregularity secondary to trauma, disease, surgery</td>
</tr>
<tr>
<td>Bandage</td>
</tr>
<tr>
<td>Occlusion</td>
</tr>
<tr>
<td>Treatment of accommodative esotropia or convergence excess</td>
</tr>
</tbody>
</table>

2. Cautions

Any patient whose clinical situation suggests increased risk of ocular infection or inflammation, but who insists on cosmetic CL fitting, should give formal informed consent before the clinician provides CLs. Several factors could limit a patient’s suitability for CL wear, as discussed below. (Table 2)

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a. Ocular Considerations

Cosmetic CL wear should be approached cautiously with patients who present with any active anterior segment disease, especially ocular (or adnexal) inflammation, infection, or severe dry eye conditions, because of the possible increased risk of complications, especially corneal NV or infection. Such diseases include acne rosacea, Sjögren syndrome, atopic dermatitis, corneal exposure, severe blepharitis, conjunctival cicatrizing disorders, neurotrophic keratitis, dacryocystitis, and patent filtering blebs. Therapeutic CLs are occasionally used as bandages, however, in these and other disease states.

Placing the lens directly in the precorneal tear film increases the risk of tissue compromise. CL use should therefore be approached cautiously for either the monocular patient (because of risk to the patient’s only useful eye) or for the patient who is engaged in an avocation or vocation with exposure to a particularly dirty or dry environment. Such individuals may be advised to wear protective spectacles. A mildly abnormal tear layer, whether insufficient in volume or of poor quality, decreases the likelihood of successful and asymptomatic CL wear, but CLs should be considered in the context of patient motivation and other relevant indications. Some forms of abnormal tear layers can be treated with supplemental artificial tear drops or ointments and mechanical or thermal occlusion of the nasolacrimal punctae (See Section IIB4b).

b. Systemic Considerations

Other indications for caution include the patient’s inability to manipulate and care for CLs appropriately or to return for appropriate professional supervision. Contact lens wear should be approached cautiously with the patient who has immunosuppressive disease (e.g., AIDS), rheumatoid arthritis, or diabetes, which may lead to insufficient lacrimation or increased risk for corneal NV and infections.
c. Noncompliant Patients

Clinicians should exercise caution, and occasionally exercise restraint, when considering CL fitting for patients known or suspected to be so noncompliant with appropriate CL care and general hygiene as to place themselves at increased risk for severe complications (See Section IIE1).

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Table 2
Reasons for Caution with Contact Lenses

<table>
<thead>
<tr>
<th>Ocular (local)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active anterior segment disease, especially infection (e.g., severe blepharitis or dacryocystitis)</td>
</tr>
<tr>
<td>Dry eye* possibly associated with Sjögren syndrome secondary to rheumatoid arthritis, lupus, thyroid disease</td>
</tr>
<tr>
<td>Acne rosacea</td>
</tr>
<tr>
<td>Atopic dermatitis</td>
</tr>
<tr>
<td>Active filtering blebs</td>
</tr>
<tr>
<td>Decreased corneal sensitivity (e.g., neurotrophic)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Systemic</th>
</tr>
</thead>
<tbody>
<tr>
<td>The presence of only one visually useful eye</td>
</tr>
<tr>
<td>Diabetes</td>
</tr>
<tr>
<td>Immunosuppression</td>
</tr>
<tr>
<td>Inability to care for CLs or to present periodically for professional care</td>
</tr>
</tbody>
</table>

* Mild dry eye is a relative contraindication, which appears to increase the risk of CL failure or intolerance, but severe dry eye increases risk of secondary tissue compromise such as infection or NV.
3. Types of Contact Lenses

The majority of CLs fall into one of two main categories: hydrogel or rigid. These CLs are available in a wide variety of parameters for both spherical and spherocylindrical corrections. There are also several “hybrid” CL designs and materials.

a. Hydrogel Lenses

Spherical hydrogel CLs are indicated for the correction of myopia and hyperopia when astigmatism is limited to less than 1.00 diopter (D)21,22 and tears are sufficient. Stock optical powers are commonly available between +6.00 D and -20.00 D; higher custom powers are also available (e.g., for cases of aphakia). Some hydrogel CLs, depending upon their power and thickness profiles, may be difficult for some patients to insert and remove.

The U.S. Food and Drug Administration (FDA) has classified all hydrogel materials into four groups,23 which are believed to behave the same chemically (Table 3). Oxygen permeability (Dk) of the hydrogel materials in all groups increases with water content (WC)24. Oxygen transmissibility (Dk/t) is lens specific, thus directly dependent on both the WC (hence Dk) of the CL’s material and the reciprocal of its individual thickness (t) profile.25-28 Another class of hydrogel CL materials, in which silicone (for enhanced Dk) is blended with hydrogel materials (for comfort), is also available.29

<table>
<thead>
<tr>
<th>Group 1 Low Water Content</th>
<th>Group 2 High Water Content</th>
<th>Group 3 Low Water Content</th>
<th>Group 4 High Water Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonionic</td>
<td>Nonionic</td>
<td>Ionic</td>
<td>Ionic</td>
</tr>
<tr>
<td>Crofilcon</td>
<td>Alphafilcon A</td>
<td>Balafilcon A</td>
<td>Bufilcon A</td>
</tr>
<tr>
<td>Dimefilcon A</td>
<td>Altrafilcon</td>
<td>Bufilcon A</td>
<td>Etafilcon A</td>
</tr>
<tr>
<td>Genfilcon A</td>
<td>Ofilcon A</td>
<td>Deltafilcon A</td>
<td>Focofilcon A</td>
</tr>
<tr>
<td>Hefilcon A &amp; B</td>
<td>Omafilcon A</td>
<td>Droxifilcon A</td>
<td>Methafilcon A, B</td>
</tr>
<tr>
<td>Hioxifilcon B</td>
<td>Seafilcon A</td>
<td>Etafilcon A</td>
<td>Ocuofilcon B</td>
</tr>
<tr>
<td>Iotrafilcon A</td>
<td>Surfilcon A</td>
<td>Ocuofilcon A</td>
<td>Ocuofilcon C</td>
</tr>
<tr>
<td>Isofilcon</td>
<td>Vascular A</td>
<td>Ocuofilcon A</td>
<td>Ocuofilcon D</td>
</tr>
<tr>
<td>Mafilcon</td>
<td>Xylofilcon A</td>
<td>Phemfilcon A</td>
<td>Ocuofilcon E</td>
</tr>
<tr>
<td>Polymacon</td>
<td></td>
<td></td>
<td>Perfilcon A</td>
</tr>
<tr>
<td>Tefilcon</td>
<td></td>
<td></td>
<td>Phemfilcon A</td>
</tr>
<tr>
<td>Tetrafilcon A</td>
<td></td>
<td></td>
<td>Tetrafilcon B</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vifilcon A</td>
</tr>
</tbody>
</table>

Source:
Toric hydrogel lenses\textsuperscript{30-32} are indicated for patients who are otherwise good candidates for hydrogel CLs and who wish to use CLs for cosmetic correction of refractive error, including visually significant astigmatism (usually greater than 0.75 D). Standard designs frequently correct astigmatism up to about 2.00 D; some custom hydrogel CL designs are available to correct up to about 8.00 D. Toric hydrogel lenses are more expensive than the spherical designs, and may not provide universally stable visual results.\textsuperscript{33}

Variable optical results and comfort levels may occur in patients who have insufficient tears with all types of hydrogel CLs, especially toric lenses. On the other hand, severe previous limbal desiccation at the 3 o’clock and 9 o’clock positions (“3/9” staining) from the use of rigid CLs, with or without subsequent superficial NV, is an indication for fitting both spherical and toric hydrogel CLs in the patient with adequate tears.\textsuperscript{34}

b. Rigid Lenses

Rigid corneal CLs usually provide better visual results than do hydrogel CLs in situations of either regular or irregular astigmatism of the corneal surface. Insufficient tears usually will not affect the optics of rigid CLs, but this condition does increase the prevalence of both intolerance and some physiological complications. Rigid gas permeable CL materials (Table 4) are available in a wide range of optical powers, oxygen permeability,\textsuperscript{35} plastic “hardness,” wettability, and specific gravity, all of which affect lens design and positioning.\textsuperscript{36} Usually, the more oxygen permeable the plastic, the more fragile the finished CL. PMMA CLs are occasionally useful, although the clinician must recognize that this material has virtually no oxygen permeability and that corneal metabolism is totally dependent on tear exchange when CLs made of this material are worn. Concern about hypoxia in patients with corneal grafts or previous superficial pannus, possibly from the use of hydrogel CLs of optical powers in excess of -10.00 D,\textsuperscript{37} is an indication for the use of RGP s. Clinicians should note that the use of rigid CLs may be less successful in dusty environments.

<table>
<thead>
<tr>
<th>Material</th>
<th>Optical Index</th>
<th>Specific gravity</th>
<th>Oxygen Dk*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advent</td>
<td>1.39</td>
<td>1.60</td>
<td>78</td>
</tr>
<tr>
<td>Airlens</td>
<td>1.54</td>
<td>0.99</td>
<td>20</td>
</tr>
<tr>
<td>Boston ES</td>
<td>1.443</td>
<td>1.22</td>
<td>31</td>
</tr>
<tr>
<td>Boston RXD</td>
<td>1.44</td>
<td>1.27</td>
<td>39</td>
</tr>
<tr>
<td>Boston 7</td>
<td>1.428</td>
<td>1.22</td>
<td>73</td>
</tr>
<tr>
<td>Boston II</td>
<td>1.47</td>
<td>1.13</td>
<td>20</td>
</tr>
<tr>
<td>CAB**</td>
<td>1.48</td>
<td>1.20</td>
<td>8</td>
</tr>
<tr>
<td>Equalens</td>
<td>1.44</td>
<td>1.19</td>
<td>48</td>
</tr>
<tr>
<td>Fluoroperm 30</td>
<td>1.46</td>
<td>1.12</td>
<td>28</td>
</tr>
<tr>
<td>Fluoroperm 151</td>
<td>1.442</td>
<td>1.10</td>
<td>151</td>
</tr>
<tr>
<td>Menicon SF-P</td>
<td>1.436</td>
<td>1.12</td>
<td>126</td>
</tr>
<tr>
<td>Menicon Z</td>
<td>1.437</td>
<td>1.20</td>
<td>189</td>
</tr>
<tr>
<td>PMMA</td>
<td>1.49</td>
<td>1.18</td>
<td>N/A</td>
</tr>
<tr>
<td>Polycon II</td>
<td>1.49</td>
<td>1.14</td>
<td>10</td>
</tr>
<tr>
<td>SGP II</td>
<td>1.47</td>
<td>1.10</td>
<td>40</td>
</tr>
</tbody>
</table>

Data compiled from various sources.

* In x10 E-11 cm\textsuperscript{2}mlO\textsubscript{2}/sec ml mm Hg

** CAB: Cellulose acetate butyrate
c. **Hybrid and Silicone Lenses**

Among several CL materials or designs that combine aspects of both rigid and flexible lenses are piggyback systems (wherein a rigid CL is worn over a hydrogel CL on one eye),\(^3\) non-hydrogel flexible materials (e.g., Silsoft\(^\text{TM}\)),\(^4\) and Softperm\(^\text{TM}\).\(^5\) Though not in common use, such lenses are extremely helpful in rare cases of regular or irregular corneal astigmatism (including keratoconus) or aphakia.

B. **Contact Lens Examination and Fitting**

The initial procedures in determining a CL prescription include a comprehensive eye examination to arrive at optimum refractive correction and the elimination of concerns for concurrent ocular and systemic disease.* The clinician should obtain a baseline quantification of corneal curvature ("K" values come from keratometry or videokeratography/topography measurements, and "on K" refers to the value of the flat corneal meridian). The anterior segment and tear layer should be carefully evaluated, and all pre-fitting abnormalities of the ocular and lid surfaces (e.g., corneal scars and NV, blepharitis or meibomian gland dysfunction, and palpebral conjunctival follicles or papillae) should be documented, considered, and treated, when appropriate.

1. **Fitting Different Types of Contact Lenses**

The clinician’s goal is to design a CL from a physiologically adequate material that will have minimal mechanical impact on the corneal surface while providing the required optical correction.

Although not all clinicians always use a diagnostic evaluation of trial lenses prior to ordering the CL, such a process, while both somewhat labor-and time-intensive, allows clinicians and patients to gain a better perspective on the anticipated performance, including both optical and physical/physiological tolerance, of the CLs ordered. Some clinicians

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* Refer to the Optometric Clinical Practice Guideline for the Comprehensive Adult Eye and Vision Examination.
anterior eye, but such a change might decrease the effective power of a plus-powered hydrogel lens.49,51

b. Toric Hydrogel Lenses

Toric hydrogel lenses are available in both stock (limited parameters) and custom prescriptions from many manufacturers. The clinician should first achieve a good physical fit by selection of the appropriate base curve and total diameter. The refractive astigmatic axis is stabilized by prism, truncation, superior/inferior thin zones, or a combination of methods.30-32 The astigmatic axis of the contact lens cylinder should be prescribed as close as possible to the patient’s astigmatic axis, after accounting for the estimated rotation of the lens on the eye;52 the optical power of the patient’s astigmatism can often be undercorrected without compromise to visual acuity, which may result in less visual disturbance caused by any alignment variability or misrotation.32

c. Spherical Rigid Lenses

Non-gas permeable PMMA rigid CLs are seldom provided to new wearers because of the overwhelming scientific documentation supporting the physiological need of the cornea for anterior surface oxygenation.53-57 Instead, rigid gas permeable CLs are provided in either custom or stock designs. Clinicians usually use sodium fluorescein dye to fit a RGP BCOR to show alignment with the corneal surface at a TD that will either position the CL under the upper lid (“lid attachment” fit) or cause it to ride within the palpebral aperture (“interpalpebral” fit). Such positioning is thought to minimize 3/9 corneal staining24 and lens flexure,58 while enhancing tolerance and allowing the optical benefits of a large optical zone.

When selecting the initial diagnostic RGP lens BCOR, the clinician should begin with the previously measured corneal curvature values as an initial guide. For many patients, in achieving a physically aligned fit, the more spherical the Ks, the more likely that the optimum RGP CL BCOR will be slightly flatter than the flat K. The more astigmatic the Ks, the more likely it is that the appropriate base curve will be close to the mean K. Some clinicians alternatively elect to achieve slight apical vault by selection of BCOR/TD. Changes in the BCOR of RGP CLs will directly affect the optical power of the CL/eye system and will require direct optical power compensation.

In general, the flatter, more myopic, or more astigmatic the cornea, the larger the TD that is required to achieve an optimum CL/cornea relationship and vice-versa. A TD of approximately 9.0 mm is a good starting point for most modern RGP CL designs, but clinicians effectively prescribe RGPs with TDs ranging from less than 8.0 to greater than 11.0 mm. An optic zone that approximates the same value as the BCOR (about 1.2 mm smaller than the TD) is common.

RGPs that ride low on the patient's cornea and move minimally should be avoided. Adequate CL position and movement encourage the exchange of tears, which pumps fresh oxygen from the air under the lens and washes out debris and metabolic waste. Appropriate position and adequate movement of the CL also minimize lens binding (in which adherence to the underlying corneal surface leaves a physical impression of the lens edge in the tissue). Lens binding may lead to 3/9 corneal desiccation staining, which in turn can result in peripheral corneal epithelial hypertrophy, vascularization, dellen, or even microbial infection.34,60-64

The posterior peripheral curve system should be designed to lift the edge of the CL gently off the corneal surface to provide a reservoir of tears for exchange that maintains CL movement. This prevents chafing, due to low edge lift, or drying of the peripheral cornea, due to high edge lift.65 The edge should also be well shaped and smooth.

d. Toric Rigid Lenses

Toric RGP CL designs are also available, but their application often requires more experience and expertise. Bitoric RGPs of either spherical or cylindrical power effect design are extremely useful in optimizing vision and mechanical fit primarily in cases of regular or occasionally irregular corneal astigmatism.66,67
Front-surface toric (spherical base curve) RGPs are also occasionally prescribed for residual astigmatism but clinically have a more limited role. BCOR/TD/peripheral curve systems should be chosen for proper mechanical fit. Optics should be prescribed with the astigmatic axis stabilized by the use of prism and/or truncation(s). The prescription of back-surface toric designs may also occasionally be appropriate. Many manufacturing laboratories offer consultation in fitting more complicated cases such as these.

2. Determination of Optical Power

Over-refraction of diagnostic or initial RGP or hydrogel CLs in situ, as well as consideration of binocular vision requirements, allows the clinician to optimize CL optical power. Vertex distance must be considered if the over-refraction suggests the need for change greater than +/-4.00 D. Caution should be exercised in prescribing CLs for pre-presbyopic myopic patients because the change in vertex distance results in a need for increased accommodation and convergence for near vision, often resulting in symptoms of blurred vision or ocular discomfort. The opposite effect (i.e., decreased need for accommodation and convergence) may be anticipated in fitting pre-presbyopic hyperopic patients with CLs. Contact lens power may also be calculated without an over-refraction by taking into account both the vertex distance of the manifest refraction and potential lacrimal lens power.

3. Special Design Features

The following additional design features may be required to optimize contact lens fit.

a. Lenticular Edge Modification

When RGP optical power exceeds approximately +1.00 or -6.00 D, lenticular design of the anterior CL surface may improve edge profile, decrease lens thickness and weight, and thereby improve tolerance and centration. Occasionally, patients requiring very low plus or low minus power RGP lenses will also benefit from a lenticular design (or construction). Manufacturers routinely, however, provide lenticular construction hydrogel CLs because of their large total diameters.

b. Prism and Truncation

Prescribed in CLs primarily for orientation, prism is very rarely used to address problems of binocular vision (such as vertical phoria). Only vertical, base-down prism can be used in CLs. Base-down prism is used to help orient some bifocal and front-surface toric CL designs, both rigid and hydrogel. Prism also can be used successfully to assist in lens positioning.

A truncation is a zone of the circumference of a previously circular CL that has been flattened by removal of material. The effect of truncation is similar to that of prism in decreasing CL rotation, which is most often helpful with application of bifocal or front-surface toric CLs.

c. Fenestrations

Small holes drilled through a CL are called fenestrations. They are intended to improve oxygenation either directly or by encouraging tear exchange.

d. Blending

Smoothing or blending of the junctions between curvatures on the posterior surface of RGP lenses may enhance comfort and reduces corneal chafing or trauma.

4. Special Concerns

Some areas of CL application deserve additional discussion, especially presbyopic correction, the use of CLs when eyes are “dry,” and extended wear.
**a. Presbyopia**

Bifocal CLs for presbyopia are optically complex. Successful use is subject to many patient-specific factors and the doctor's experience, skill, and willingness to persist through fitting challenges. Thus, despite recent improvements in both RGP and hydrogel designs, they still have limited utility.

Two design philosophies guide distance and near correction with bifocal contact lenses. “Simultaneous vision” bifocal (or multifocal) CLs typically require consistent optimal positioning over the patient’s pupils. In contrast, “alternating vision” lenses are intended to optimize distance vision while the patient’s eyes are in the primary position, then reliably move on the corneal surface so that a large portion of the near vision optical zone covers the pupil in downgaze.

Perhaps the most successful form of CL correction for presbyopia is "monovision," in which one eye is optimally corrected for distance acuity and the other is corrected for near vision. Use of the monovision technique has some limitations but is most effective in cases of emerging presbyopia (usually adds of +1.75 D or less) in which patients demonstrate adequate distance visual acuities in both eyes. There are many ways to decide which eye should be corrected in which manner, but the most common is selection of the dominant eye for distance correction. When difficulties are encountered, the distance/near CL fit can be reversed.

Although monovision has been shown to have very little effect on binocular fusion and visual fields, it can cause subjective visual difficulties; specifically, both stereopsis and contrast sensitivity are decreased, the latter especially with higher adds. Over-spectacles are often prescribed to optimize binocular vision for critical tasks, such as operating machinery or driving a motor vehicle. Some practitioners believe that patients should provide formal informed consent for the prescription of monovision CLs, indicating their full awareness of the risks, benefits, and visual limitations of this form of correction.

**b. Dry Eye**

Many patients with mild dry eyes may be helped to tolerate CLs. Both systemic and ocular aspects of the dry eye condition should be managed prior to and during contact lens wear. Instruction in lid hygiene and the prescription of artificial tear drops, particularly unpreserved unit doses, are two often helpful treatments. There is some evidence that contact lens wear can cause or aggravate dry eye, increasing the importance of such care.

The choice of CL material may also be important. Some clinicians believe that RGP CLs are often tolerated better over the long term than hydrogel lenses. This tolerance is primarily attributable to RGPs’ better maintenance of optics and fit, compared with hydrogel lenses, especially toric hydrogel lenses, which can undergo physical changes with dehydration. Other clinicians believe that hydrogel CLs, especially those of thicker design such as toric CLs, are associated with fewer signs and symptoms of dry eye.

Mechanical or thermal occlusion of the nasolacrimal punctae may provide significant improvement for many patients suffering from clinically significant mild dry eye.

**c. Extended Wear**

CLs have been provided for use on extended- or continuous-wear schedules for many years. Both the prevalence and severity of all complications, especially microbial infection, are increased when CL wear is extended through one or more sleep cycles, as discussed in the next section. Current FDA guidelines limit extended wear of approved lenses to no more than six nights in succession. Because of increased risk of complications, patients who elect extended CL wear should give formal informed consent.

**C. Dispensing Lenses and Patient Education**

Contact lenses should be free from defects such as scratches, chips, or tears. Prior to initial dispensing of CLs, the clinician should verify that
The Care Process

all parameters of the lenses are as ordered and that they meet established standards, such as those of the American National Standards Institute (ANSI). When appropriate, the clinician or staff should also confirm the performance of the CLs on the patient’s eyes, optically, mechanically, and physiologically.

The patient, or a parent or guardian, should be trained in lens care, maintenance, and handling. The importance of proper hygiene, compliance with CL care techniques, and appropriate follow-up under professional supervision should be stressed. Warnings, precautions, and directions for use of a contact lens are found in the patient information booklet available upon request from the lens manufacturer. Information directed to the eye care practitioner is found in the package insert or in the professional fitting guide. Other extensive literature on the proper care of CLs is available.

The patient should be taught to perform the following steps in the care and handling of a CL:

- Wash hands.
- Clean each CL by gently rubbing and thoroughly rinsing with an appropriate solution.
- Store and disinfect CLs in fresh appropriate solution for an appropriate time interval in a clean case until reinsertion in the eyes.
- Reclean and resoak CLs periodically and again preceding wear if there is an interruption in CL wear for any reason.

Discussion of these procedures and warnings should be provided in writing and documented in the patient’s record. Professional follow-up care should be scheduled.

D. Progress Evaluations

Follow-up visits are important for proper management of the patient with CLs. Planned evaluation should occur during the initial weeks and months of CL wear to allow any necessary mechanical or optical refinements in lens prescription(s), to monitor adaptation and minimize ocular complications, and to reinforce appropriate CL care. Subsequent evaluations are usually indicated at 6-to-12 month intervals for healthy patients wearing cosmetic CLs. It is advisable to see patients who may be at additional risk for ocular compromise during CL wear more often than every 6 months, perhaps every 3 or 4 months or even more frequently. Such patients include those using CLs for extended wear, those wearing CLs for treatment of eye disease (e.g., keratoconus), or following corneal trauma or surgery, and children wearing CLs for the prevention or treatment of myopia or for correction of aphakia, for example.

The clinician should recommend additional visits whenever the CL patient experiences an unexpected problem in vision or ocular condition. Emergency services should be available 24 hours a day, every day of the year, through the practitioner’s practice or through eye care, health care, or emergency room facilities.

Progress evaluations, planned or unplanned, should follow the “SOAP” format. The clinician should begin by obtaining a Subjective history of both CL wear and other concerns. The clinician should then evaluate Objective clinical findings, such as visual acuities and over-refraction results. Appropriate confrontation tests and gross observation of the eyes and adnexa should be performed at this time, followed by biomicroscopic evaluation of the lenses on the eyes and of the patient's anterior ocular segments, often with the assistance of diagnostic dyes. The clinician should periodically evaluate the corneal surface by keratometry or videokeratography/topography. Additional examinations and investigations may also be indicated. For example, a CL-wearing patient who complains of a sudden onset of "floaters" in one eye should be seen immediately to evaluate for possible retinal detachment. In cases of reduced vision that cannot be attributed to lens power or CL optical quality, ocular media and retinal assessments are indicated. The clinician can then effectively Assess the situation and Plan appropriate management steps. The clinician should monitor refraction and general ophthalmic health at whatever normal schedule is appropriate for the patient's situation.
During progress evaluations of RGP wearers, the prescribed parameters of the CLs should be periodically verified and the lenses reconditioned (polished) to reduce both soilage and scratches when necessary. When CLs are found to have been damaged or changed during use (e.g., any cracks or edge chips, and/or warpage or flattening/steepening of BCORs greater than 0.1 mm<sup>85</sup>), replacement of the CL is advised.

### E. Management of Complications Associated with Contact Lens Wear

Fortunately, CL wearers rarely experience vision-threatening complications directly associated with wearing CLs. Because full discussion of the complications that have been associated with wearing CLs is beyond the scope of this Guideline, standard textbooks should be consulted for more in-depth information.<sup>86,87</sup>

The first step in proper management of the CL wearer who experiences complications is correct diagnosis. The second step is clinical grading of the severity of an observed complication or response to CL use.<sup>88</sup> After accurate diagnosis and grading (Table 5), appropriate management and clinical supervision can be provided.

<table>
<thead>
<tr>
<th>Grade*</th>
<th>Interpretation</th>
<th>Clinical Approach Advised</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Normal: no tissue changes observed</td>
<td>No action required; routine clinical progress evaluation suggested.</td>
</tr>
<tr>
<td>1 (minimal)</td>
<td>Trace: minimal if any tissue changes</td>
<td>Minimal, if any, change in CL wear/care suggested; observation encouraged.</td>
</tr>
<tr>
<td>2 (mild)</td>
<td>Definite tissue changes observed</td>
<td>Initiate clinical measures to address complication; observe clinical response.</td>
</tr>
<tr>
<td>3 (moderate)</td>
<td>Modest tissue changes observed; ocular damage possible</td>
<td>Decrease or discontinue CL wear and treat complication; restart CL wear with appropriate changes in wear/care when complication successfully reversed. Provide professional supervision.</td>
</tr>
<tr>
<td>4 (severe)</td>
<td>Ocular damage probable</td>
<td>Discontinue CL wear and treat complication appropriately; consider risk/benefit ratio of restarting CL wear in the future.</td>
</tr>
</tbody>
</table>

Based on:
Note: this is an ordinal and not integer scale.
* Ordinal scaling implies that a Grade 3 response is greater than a Grade 2; however, the interval between Grades 1 and 2 may not be the same as the interval between Grades 2 and 3.
1. General Considerations

The most effective way to address the complications of CL wear is to prevent them from occurring. One method of precluding many complications is to maintain CL care and hygiene, consistent with both common sense and FDA-approved manufacturers’ guidelines. Achieving and maintaining total patient compliance with recommended CL care, however, is often difficult.

CL soilage or solution reactions, and their secondary complications, can be avoided by use of “disposable” CLs. These hydrogel lenses are manufactured through molding technology which maintains high-quality design standards and has reduced the cost of lenses to the extent that daily replacement of lenses has become a practical option for some patients. Prescribing disposable CLs has the advantage of maximizing patient convenience while minimizing the possibility of solution reactions. RGP CLs can usually be reconditioned by polishing and cleaning, but they sometimes become warped, scratched, or soiled to an extent that is beyond office rehabilitation.

Most complications of CL wear increase in both prevalence and severity when patients wear them on an extended or continuous basis. Therefore, restricting CL use to daily wear whenever possible is a means of minimizing the occurrence of these complications.

Many of the complications of CL wear are also accompanied, and in some cases at least partially caused, by lid diseases such as blepharitis, meibomian gland dysfunction, and dry eye. Treatment of underlying lid disease and dry eye by improving lid hygiene, the use of artificial tear drops (often in unpreserved unit doses), punctal occlusion, and appropriate antibiotic treatment, either locally or systemically, is helpful in minimizing many of the complications of CL wear.

Many of the complications of CL wear can be treated effectively by temporary discontinuation of CL wear. Reversal of inflammatory lid and conjunctival reactions and solution sensitivities, collapse of mild forms of corneal NV, and healing of corneal epitheliopathies often occur without additional treatment. The use of adjunctive medical therapy, consisting of artificial tears, nonsteroidal anti-inflammatory drugs (NSAIDs), mast cell stabilizers, antibiotics, and occasionally even steroid drops, should be considered.

Special precautions should be taken to avoid the spread of infection from one patient to another in the practitioner’s office. These measures should include appropriate cleaning and the disinfection of diagnostic CLs and adjunctive equipment, especially tonometers. Disinfection must be performed by a method approved by the U.S. Centers for Disease Control and Prevention (CDC).

2. Noninfectious Complications

By far, the most prevalent complications of CL wear are associated with lens care and solutions and CL spoilage, particularly in the case of hydrogel lenses (Table 6).
### Table 6

**Noninfectious Complications of Contact Lens Wear***

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Complication</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lids</td>
<td>Toxicity</td>
<td>Usually a solution reaction</td>
</tr>
<tr>
<td></td>
<td>Allergy</td>
<td>Usually a solution reaction (type IV Gell-Coombs hypersensitivity)</td>
</tr>
<tr>
<td></td>
<td>GPC: Type I Gell-Coombs hypersensitivity, related to CL deposits/edge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ptosis</td>
<td>Associated with GPC or RGP wear</td>
</tr>
<tr>
<td></td>
<td>Blepharitis/ meibomian gland dysfunction</td>
<td>Lid inflammation, related to bacterial or noninfectious etiology; not CL-caused but can complicate care and lead to dry eye symptoms, soiled CLs, lid and eye infections.</td>
</tr>
<tr>
<td>Bulbar conjunctiva</td>
<td>Injection</td>
<td>Usually a solution reaction; toxicity or allergy; possibly CL hypoxia, dry eye.</td>
</tr>
<tr>
<td></td>
<td>Edema</td>
<td>Usually a solution reaction; toxicity or allergy.</td>
</tr>
<tr>
<td></td>
<td>Staining</td>
<td>From lens edge, desiccation.</td>
</tr>
<tr>
<td>Corneal epithelium</td>
<td>3/9 stain</td>
<td>Primarily associated with low-riding RGP; also evaluate edge lift, shape, position, tears, and lids; possibly leads to dellen, NV, VKL-pseudopterygium.</td>
</tr>
<tr>
<td></td>
<td>Pancorneal stain</td>
<td>Medicamentosa, dirty CL, solution toxicity or sensitivity; consider viral infection.</td>
</tr>
<tr>
<td></td>
<td>Superior epithelial arcuate lesion (SEAL)</td>
<td>Always in association with hydrogel CLs; possibly dirty or tight CL (also called epithelial splitting).</td>
</tr>
<tr>
<td></td>
<td>Inferior arcuate stain</td>
<td>Dehydration through hydrogel lens.</td>
</tr>
<tr>
<td></td>
<td>Foreign body track</td>
<td>Foreign body between CL and cornea or under upper lid.</td>
</tr>
<tr>
<td></td>
<td>Cluster overwear stain</td>
<td>Central corneal hypoxia and secondary stain from nonpermeable HCL wear.</td>
</tr>
<tr>
<td></td>
<td>Inferior band stain</td>
<td>Corneal exposure or blepharitis (non-CL wear).</td>
</tr>
<tr>
<td></td>
<td>Abrasion</td>
<td>Deep or coalesced epithelial defect, usually with symptoms (pain, foreign body sensation) but without infiltrate.</td>
</tr>
<tr>
<td></td>
<td>Dimple veil</td>
<td>Saucer-shaped depressions in epithelium from bubbles trapped between CL and cornea.</td>
</tr>
</tbody>
</table>
Table 6 (Continued)

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Complication</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infiltration</td>
<td>First consider infection; also consider solution sensitivity, herpes simplex keratitis (HSK), Thygeson disease, etc.</td>
<td></td>
</tr>
<tr>
<td>Edema</td>
<td>CL hypoxia causing CCC, ECF, microcysts, microcystic edema.</td>
<td></td>
</tr>
<tr>
<td>Deep stromal striae</td>
<td>Similar to keratoconus; Vogt’s striae at ~4-6% swelling; striae keratopathy at Descemet’s membrane at ~10% swelling; also consider endothelial cell dysfunction (e.g., Fuchs corneal dystrophy) or glaucoma.</td>
<td></td>
</tr>
<tr>
<td>Neovascularization (NV)</td>
<td>Pseudopterygium at 3/9 stain (associated with RGP wear); pannus (associated with hypoxia from hydrogel wear); possibly deep stromal NV.</td>
<td></td>
</tr>
<tr>
<td>Infiltration</td>
<td>First consider bacterial, amoebic, or fungal infection; rule out solution reaction, HSK, adenovirus, Chlamydia, Epstein-Barr virus, Lyme disease, etc.</td>
<td></td>
</tr>
<tr>
<td>Corneal endothelium</td>
<td>Deformation in endothelial cells associated with acute hypoxia.</td>
<td></td>
</tr>
<tr>
<td>Polymegethism</td>
<td>Change in endothelial cell size or shape associated with chronic hypoxia.</td>
<td></td>
</tr>
</tbody>
</table>

* Always consider masquerade syndromes

Another common complication of CL wear is hypoxia, which induces changes at all corneal layers. These changes include microcysts and microcystic edema (MCE); central circular clouding (CCC); pseudodendritic edematous corneal formations (ECF); decreased epithelial mitosis, sensitivity and adhesion; changes in stromal thickness, acidosis, and striae; and endothelial blebs and polymegethism. In a postulated corneal exhaustion syndrome (CES), previously successful long-term CL wearers suddenly become intolerant of additional CL wear.

Superficial corneal pannus is associated with either chronic hypoxia or chronic 3/9 epithelial desiccation (rigid CLs). Secondary intracorneal hemorrhages can occur. Deep stromal NV is a very rare complication.

CL wear can lead to distortion and warpage of the corneal surface, which results in “spectacle blur” or a reversible loss of good spectacle acuity immediately following CL wear. Clinicians also often observe “dimple veil” epithelial depressions from bubbles of air trapped between CLs and the ocular surface.

True epithelial “staining” represents some epithelial cell layer disruption, which can progress to occasional erosions and even abrasions. Etiological factors may be obvious -- chemical trauma (e.g., solution reactions), mechanical trauma (e.g., damaged CLs, foreign bodies trapped between the CL and the eye), or superior epithelial arcuate lesion (SEAL or “epithelial splitting”) -- or obscure. Some brands of CLs cause distinctive staining patterns without progressing. Clinicians should consider either keratoconus or Cogan’s microcystic-map-dot-fingerprint dystrophy in any patient who presents with an abrasion without a clear-cut historical etiology (See Appendix Figure 1).

Corneal infiltrates, both round and dendritic, may be signs of solution sensitivity, true corneal microbial infection, or even unrelated complications. The clinician should always be alert to the possibility of herpetic or Acanthamoeba infection masquerading as a more benign CL complication (See Appendix Figure 2).
Documented lid reactions include allergic responses such as giant papillary conjunctivitis (GPC)\textsuperscript{133,134} or ptosis.\textsuperscript{135-139} The conjunctiva is also subject to many types of toxic and allergic reactions, some totally and others partially, due to the use of CLs and their care solutions.\textsuperscript{129-131,140-145} The clinician should always be careful to consider masquerade syndromes (e.g., drug abuse or herpetic disease).\textsuperscript{43,131,132}

The clinical challenge is often to maintain CL wear in the face of five specific types of noninfectious complications, as discussed in the following paragraphs.

\textbf{a. Solution Reactions}

The majority of these problems are cell-mediated (Gell-Coombs type IV) reactions to preservatives,\textsuperscript{130} but the anterior segment signs are often nonspecific. Solution reactions often present with both fine corneal staining, with or without infiltrates, and conjunctival injection and/or edema. When the clinician suspects such a reaction, CL wear should be discontinued, and appropriate treatment and professional observation should be initiated. After reversal of the reaction, the clinician may initially try substituting one product or class of product for another. When this measure fails, hydrogel CL wearers may be fitted with daily disposable CLs to eliminate all solution issues. RGP wearers can use aerosol-packaged nonpreserved saline to rinse their lenses copiously prior to insertion. For fear of an \textit{Acanthamoeba} infection, the use of tap water or fresh water rinses is discouraged. If water is utilized for rinsing RGPs, an additional rinse with sterile saline or conditioning solution is recommended (See Appendix Figure 3).

\textbf{b. Hypoxia}

In the mid-1970s, all rigid CLs were made of non-oxygen-permeable PMMA, and early hydrogel lenses all had modest oxygen transmissibility. Hypoxia was a common complication. Most of the RGP and hydrogel CLs now available, however, generally do not cause corneal hypoxia under daily wear conditions. When there is clear evidence of hypoxic corneal changes (e.g., epithelial or stromal edema, corneal pannus\textsuperscript{37} greater than approximately 2 mm unrelated to \(3/9\)

\textbf{c. Three O’clock and Nine O’clock Staining}

Perhaps the most common complication of RGP wear is \(3/9\) staining. Even moderate to severe \(3/9\) staining deserves attention to decrease the potential for this complication to advance to infection, dellen, or pseudopterygium/vascularized limbal keratitis (VLK). The principal cause of \(3/9\) staining is low-riding RGP CLs. Therefore, an effort should be made to optimize the position of the CL by increasing its TD and/or flattening its BCOR. For cases of substantial corneal astigmatism, bitoric RGP designs may be considered. When the CL centers well, the clinician should consider modifying the edge lift associated with the peripheral curve design, the edge thickness, and/or the TD.\textsuperscript{147} The clinician should also consider whether CL binding is playing a role in the development of this corneal epitheliopathy.

The condition of the patient’s lids/meibomian glands and tear layers often contributes to \(3/9\) staining and should also be addressed (as discussed previously). Lens position and wearing time should be managed. When all attempts to solve the problem with RGPs are unsuccessful, and when there are no contraindications, the prescription of hydrogel CLs may also be considered\textsuperscript{14} (See Appendix Figure 5).

\textbf{d. Corneal Abrasion}

Corneal epithelial abrasion is a common occurrence among CL wearers. The clinician can expect to spend approximately one percent of CL-related office visits treating abrasions; more in practices where keratoconic patients are numerous.\textsuperscript{127} Treatment consists of first ruling out infection and temporarily discontinuing CL wear. Some clinicians believe in prophylactic antibiotic treatment, while others prefer to withhold antibiotics unless infection is suspected or proven. To decrease the risk of precipitating or enhancing a microbial corneal infection, the clinician should neither patch nor use topical steroids to treat a CL-
associated abrasion (See Section IIE3a). Close professional supervision is prudent until the epithelial defect has closed and the etiology of the abrasion should be considered before CL wear is resumed. For example, when the cause of the abrasion appears to be the patient’s failure to insert or remove the CLs properly, reinstruction in these procedures should precede CL redispensing. Management of the patient with repeated apical corneal abrasions, may require refitting of the CLs with steeper BCORs or the use of piggyback CL systems (See Appendix Figure 6).

e. Giant Papillary Conjunctivitis

Giant papillary conjunctivitis has been shown to be a Gell-Coombs type I hypersensitivity reaction. Type I reactions imply that conjunctival mast cells, presensitized by immunoglobulin E (IgE) generated by a previous encounter, are activated by a second antigen presentation. The GPC antigen has never been identified but is understood to be related to either biological debris adherent to the surface of a CL or perhaps to mechanical conjunctival irritation from the edge of the CL itself.

If at all possible, the patient diagnosed with GPC should first discontinue CL wear until he or she is symptom (itching) free and the signs (mucus, inflammatory tarsal conjunctival papillae) are subsiding. CL wear may then be resumed cautiously, with improved CL cleaning (e.g., more frequent, increased use of enzyme cleaner). The use of peroxide disinfection or daily-disposable CLs is helpful for hydrogel wearers. Often it is also helpful to change the CL design from hydrogel to RGP or vice-versa, or at least the edge design. Finally, topical mast cell-stabilizing agents, NSAIDs, antihistamines, and occasionally steroids (with caution to minimize the risk of secondary ocular infection, glaucoma, or cataract) may be prescribed adjunctively for those patients who on maximal nonmedical treatment still show signs or symptoms and for whom CL wear cannot be discontinued (e.g., those with keratoconus) (See Appendix Figure 7).

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3. Infectious Complications

Corneal microbial infection, which has an incidence of about 21 of every 10,000 people using CLs for extended-wear and about 4 per 10,000 people using CLs for daily-wear per year, is probably the CL-associated complication of most concern to both patients and practitioners. Microbial corneal infections are identified by the symptoms of ocular pain and photophobia and by the observation of clinical signs such as corneal epithelial defects in association with underlying inflammatory infiltration, often accompanied by anterior chamber reaction (including hypopyon in some cases), conjunctival discharge, lid swelling, and conjunctival injection.

Corneal infection is a potentially blinding disease, but fortunately, it is rarely encountered when the use of CLs is restricted to daily wear with good care and hygiene. When suspected or diagnosed, such lesions deserve immediate aggressive treatment and management. Whenever any of the signs or symptoms of corneal infection occur, contact lens wear should be discontinued in both eyes to decrease the potential for bilateral disease.

a. Bacterial Infections

Corneal infections associated with CL wear are usually bacterial, primarily attributable to the Gram-negative Pseudomonas aeruginosa, but also commonly due to Gram-positive Staphylococcus aureus and Staphylococcus epidermidis. Other bacteria are also occasionally cultured from such lesions. Bacterial corneal infection has been primarily associated with wearing CLs through one or more sleep cycles (extended or continuous wear).

Poor compliance with appropriate CL care procedures also appears to be a major risk factor for microbial infection (especially Acanthamoeba as discussed in the next section).

Traditional management of corneal ulcers and severe infections begins with the acquisition of cultures on blood and chocolate agars, on Sabouraud’s medium (for fungi), or on thioglycolate medium (for
anaerobes), with Gram-staining of smears for microscopic evaluation. A
stereiled Kimura spatula is used to acquire material for these laboratory
testings by scraping the leading edge of the corneal ulcer.
Aggressive topical treatment should begin with dual therapy: specially
prepared fortified topical aminoglycosides (e.g., gentamicin, tobramycin,
amikacin) to attack Gram-negative bacteria and cephalosporins (e.g.,
cefazolin) or vancomycin to destroy Gram-positive bacteria. Treatment may be modified by observation of the patient’s clinical
course and the laboratory identification of likely microorganisms and
their antibiotic sensitivities. Adjunctive patching and early steroid
treatment are usually contraindicated.

Topical fluoroquinolone antibiotics (e.g., ciprofloxacin, ofloxacin) were
introduced into ophthalmic care in the early 1990s and initiated
treatment evolution. Several studies discussed the clinically successful
use of 0.3% commercial-strength topical fluoroquinolone antibiotics as
monotherapy for suspected bacterial corneal infections without cultures,
especially when the lesions were relatively small (< 2 mm), and neither
central nor deep. Many clinicians found fluoroquinolone
monotherapy to be as effective as fortified dual therapy, and initial
cultures were believed unnecessary in many cases.

Emerging resistance to the fluoroquinolone antibiotics has been a
theoretical concern, however, and recently was reported. Some
clinicians are now discussing a new form of dual therapy, utilizing both
fluoroquinolone and cephalosporin agents, for example. Treatment of
bacterial corneal infection therefore remains an area of some controversy
and of evolving strategies, and clinicians are advised to maintain
vigilance.

b. Acanthamoeba Infections

The clinician should always consider the possibility of Acanthamoeba
species infections in any CL-related keratitis, especially in cases of
chronic disease with initially negative culture results and failure to
respond to antibiotic therapy. Clinical suspicion should be increased
when the patient reports extreme ocular pain and/or a history of exposing
the CLs to nonsterile water, or when an unusual epitheliopathy

(reminiscent of herpetic epithelial disease) or peripheral corneal radial
neuropathy is observed. Special culture techniques are available
for Acanthamoeba infections, but tissue biopsy is often necessary.

Combinations of the following four types of pharmacological agents
have been used successfully for medical treatment of Acanthamoeba
keratitis:

- **Antibiotic/aminoglycoside**: paromomycin, neomycin
- **Antifungal**: clotrimazole, ketoconazole, itraconazole, miconazole, flucnazole
- **Antiparasitic/aromatic diamidine**: propamidine isethionate, hydroxystibamidine, hexamidine di-isethionate
- **Biocide/cationic antiseptic**: polyhexamethylene biguanide, chlorhexidine gluconate, povidone-iodine.

Misdiagnosis and medical failures in the treatment of Acanthamoeba
infections are common.

c. Fungal Infections

Fungal corneal infections are extremely rare among cosmetic CL
wearers. Most cases reported in the literature have involved the use of
bandage CLs or chronic treatment with topical steroids in patients
suffering from concurrent ocular disease (e.g., neurotrophic epithelial
defects, diabetes, trauma). Antifungal pharmaceutical agents (both
commercial and custom-made) are available, but medical treatment is
often quite difficult and prone to failure. It is important to note that
atypical mycobacterium and Acanthamoeba infections often mimic
fungal corneal ulcers and vice-versa.

d. Viral Infections

Concomitant viral corneal infections, of which adenovirus and herpes
simplex virus are of principal concern, can occur during CL wear. No
causative association has been uncovered for such viral infections, but
CL wear should be discontinued during viral infections unless the CL is
being used in a treatment protocol. Adenovirus infection is usually
successfully managed by supportive therapy such as tear supplements and topical decongestants or by steroid therapy, as the clinical condition indicates. Effective antiviral agents are available for the treatment of herpetic eye disease. The clinician who observes an apparent herpetic keratitis in association with use of CLs, however, should always consider the possibility of *Acanthamoeba* as an alternative infectious agent.

It is prudent to consider discarding CLs that have been worn during the period of viral infection and dispense new CLs once the infection has resolved. Otherwise, some effort should be made to disinfect CLs, perhaps by soaking them in an appropriate disinfecting solution (e.g., CL-grade 3% hydrogen peroxide) for 10-15 minutes.

More aggressive medical treatment, including subconjunctival injections and/or systemic antibiotic treatment, hospitalization, and perhaps corneal transplantation, may be necessary, especially in cases of indolent, refractory, or non-bacterial corneal infections. The referral of patients with severe inflammatory or infectious ocular disease to a specialist in corneal and external eye diseases is prudent.
CONCLUSION

Individuals with refractive error seek improved visual acuity to enhance their perception and enjoyment of the world. Alternatives for vision correction include spectacles, contact lenses, and refractive surgery. Enhanced materials and designs have made CLs a practical option for the majority of patients who are motivated to use them. Because these lenses float within the tear layer, in intimate contact with the anterior ocular surface, great care should be taken in the prescription and application of CLs, and in the supervision of patients who wear them.

Complications that can threaten vision and persist after CL removal, such as active microbial keratitis and deep stromal NV, are rare. Limiting the use of prescribed CLs to daily wear, with adequate professional supervision, and patient compliance with both the principles of good personal hygiene and the published advice of the manufacturers of CLs and solutions, results in CL wear that is safe for the vast majority of patients.

III. REFERENCES

References 43


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References


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Figure 1
Corneal Stain

- **CORNEAL STAIN**
  - With infiltrates
    - YES: Suspect microbial infection
    - NO: Initiate appropriate diagnostic procedures and treatment immediately
  - Non-CL related
    - Superior
    - Inferior
    - Foreign body (tracks)
    - Solutions/medicaments (scattered punctate)
    - Cluster/overwear (central)
  - CL related
    - 3-9 o'clock staining
    - See abrasion flow chart
  - Abrasion (no infiltrates)
    - See abrasion flow chart

- Bacterial keratoconjunctivitis
- Allergic keratoconjunctivitis
- Viral keratoconjunctivitis
- SLK

Figure 2
Corneal Infiltrates

- **CORNEAL INFILTRATES**
  - Whitish material in the normally clear cornea, presumably consisting of inflammatory cells (e.g., neutrophils, lymphocytes) and/or microorganisms (e.g., bacteria, fungi)
  - ALWAYS RULE OUT HERPES STROMAL KERATITIS
  - DISTINGUISH FROM SCARS, CORNEAL DYSTROPHIES, ETC.

- Larger, single, central lesions
  - Overlying epithelial defects
  - Pain
  - Photophobia
  - Discharge
  - Anterior chamber reaction
  - + Conjunctival injection
  - + Lid reaction

- Smaller, multiple, peripheral lesions
  - + Conjunctival reaction
  - No anterior chamber reaction
  - + Lid reactions

- Discontinue CL wear
- CL (solution) reaction?
  - Monitor closely
    - No treatment or
    - Artificial tears or
    - Topical steroids if absolutely noninfectious
  - With resolution of signs/symptoms, restart CL wear with changes in solution and care, and close supervision

- If poor response to treatment consider herpes simplex keratitis, fungi, atypical microbacteria treatment, Acanthamoeba
- With resolution of signs/symptoms, restart CL wear with changes in solution and care, and close supervision

- **PROBABLE CORNEAL INFECTION**
  - CONSIDER BACTERIA
    - Especially *Pseudomonas*, *Staphylococcus*, *Streptococcus*
    - CONSIDER ACANTHAMOEBIA
    - Especially if daily wear, poor CL care, pain, or history of exposure to unsterilized H2O
  - Monitor closely
    - No treatment or
    - Artificial tears or
    - Topical steroids if absolutely noninfectious

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**Figure 3**
Conjunctival Injection (Conjunctivitis)

**CONJUNCTIVAL INJECTION (CONJUNCTIVITIS)**
- Without corneal changes
- Without anterior chamber reaction

CL Problem?

**YES**
- Decrease or discontinue CL wear, e.g., change from extended wear to daily wear
- CL hypoxia
- CL solutions sensitivity
- Tear-lid problems

**NO**
- Discontinue CL wear
- Differentiate diagnosis of red eye
- Bacterial conjunctivitis
- Viral conjunctivitis
- Allergic conjunctivitis
- Uveitis
- Glaucoma

**Figure 4**
Contact lens induced Corneal Hypoxia

**CL-INDUCED ACUTE CORNEAL HYPOXIA**
- Epithelial haze
- Microcystic edema
- Stromal thickening (acute)
- Striae
- Conjunctival injection
- Central corneal clouding

**CHRONIC CORNEAL HYPOXIA**
- Corneal exhaustion syndrome
- Pannus
- Edematous corneal formation
- Corneal warpage

Decrease CL wear, e.g., reduce from extended wear to daily wear

- RGP CLs
- Hydrogel CLs

- Increase Dk/t
- Increase tear exchange by:
  - Decrease CL TD
  - Increase CL movement
  - Increase edge lift

- Increase H2O content without increasing contact lens thickness
- Refit to RGP, silicone hydrogel CLs
Figure 5
"3/9" or Juxtaposition Corneal Stain

1. RGP rides too low on cornea
2. RGP edge lift too high or too low
3. RGP edge too thick or blunt
4. Insufficient RGP movement
5. Lid problems, including poor tear quality, poor tear quantity, lid disease
6. If all treatment fails, greater than clinical grade 2, "3/9" stain persists, and patient has adequate tears

Adjust edge lift by re-edging or by changing peripheral curve system

- Increase CL diameter
- Decrease optical zone diameter/haptic zone optic diameter
- Flatten base curve to obtain lid attachment

- Thin edge by use of CN bevel
- Change peripheral curves
- Change diameter
- Flatten base curve peripheral curves
- Increase or decrease diameter
- Train patient to blink better
- Provide artificial tears (nonpreserved unit dose)
- Address lid hygiene
- Treat with antibiotics
- Consider punctal occlusion

- Consider hydrogenated CL fitting
- Discontinue CL wear

Corneal Abrasion

- Coalesced or deep epithelial defect, usually associated with symptoms of pain or foreign body sensation.
- May be associated with:
  - Cracked, chipped, torn, poorly blended contact lens
  - Foreign body experience
  - Keratoconus, map-dot-fingerprint or other corneal dystrophy
  - Deposits on RGP posterior surface

Discontinue CL wear
Noninfectious abrasion

- Small epithelial defects
  - Symptoms minimal to none
  - Provide artificial tears
  - Follow-up within 24 hours
  - Advise patient to report on any symptoms

- Large epithelial defects
  - Symptoms increasing
  - Provide artificial tears
  - Advise patient to report on any symptoms

Abraision associated with:
- Corneal infiltrates
- Conjunctival reaction
- Lid edema
- Anterior chamber reaction
- Pain
- Photophobia
- Discharge

- Consider prophylactic antibiotics
- Consider bandage SCL/NSAMs
- Follow closely until epithelial defect healed
- Do not patch or apply steroids
- Advise patient to report any symptoms

Suspect corneal microbial infection

Initiate aggressive diagnostic and treatment measures immediately
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Figure 7
Giant Papillary Conjunctivitis

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  macula interfering with central vision

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Corneal abrasion
Superficial laceration

Excludes: corneal injury due to contact lens (371.82)

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Abbreviations of Commonly Used Terms

AEL Axial edge lift
ANSI American National Standards Institute
BCOR Back central optical radius
CCC Central circular clouding; also central corneal clouding
CDC Centers for Disease Control and Prevention
CES Corneal exhaustion syndrome
CL(s) Contact lens(es)
D Diffusion coefficient or Diopter of optical power
Dk Oxygen permeability
Dk/t Oxygen transmissibility
ECF Edematos corneal formation
FDA U.S. Food and Drug Administration
FST Front surface toric lens
GPC Giant papillary conjunctivitis
HEMA Hydroxyethylmethacrylate
HSK Herpes simplex keratitis
HVID Horizontal visible iris diameter
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>IgE</td>
<td>Immunoglobulin E</td>
</tr>
<tr>
<td>K</td>
<td>Quantification value of corneal curvature, by keratometry or videotopography</td>
</tr>
<tr>
<td>MCE</td>
<td>Microcystic edema</td>
</tr>
<tr>
<td>NSAIDs</td>
<td>Nonsteroidal anti-inflammatory drops</td>
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<tr>
<td>NV</td>
<td>Neovascularization</td>
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<tr>
<td>On K</td>
<td>Flat keratometry measurement</td>
</tr>
<tr>
<td>PKP</td>
<td>Penetrating keratoplasty</td>
</tr>
<tr>
<td>PMMA</td>
<td>&quot;Hard&quot; polymethyl methacrylate</td>
</tr>
<tr>
<td>REL</td>
<td>Radial edge lift</td>
</tr>
<tr>
<td>RGP</td>
<td>Rigid gas permeable</td>
</tr>
<tr>
<td>SEAL</td>
<td>Superior epithelial arcuate lesion</td>
</tr>
<tr>
<td>SOAP</td>
<td>Subjective, objective, assess, plan</td>
</tr>
<tr>
<td>t</td>
<td>Thickness of individual CL, often at the center</td>
</tr>
<tr>
<td>TD</td>
<td>Total diameter</td>
</tr>
<tr>
<td>VLK</td>
<td>Vascularized limbal keratitis</td>
</tr>
<tr>
<td>WC</td>
<td>Water content</td>
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**GLOSSARY**

**Abrasion** A defect in the corneal epithelium, usually accompanied by subjective pain or foreign body symptoms, but not infiltrates.

**Acne rosacea** A chronic inflammatory skin condition of the face, involving mild to persistent erythema and extensive hyperplasia of the sebaceous glands (with deep papules and pustules) accompanied by telangiectasia.

**Aphakia** Absence, usually postsurgical, of the crystalline lens of the eye.

**Artificial tears** Lubricating drops prepared to supplement the normal tear layer, often containing chemicals to adjust pH, viscosity and other nutritional constituents to mimic the normal tear layer. Can be nonpreserved (sterility achieved by the use of unit dosage) or preserved with a variety of agents.

**Aspheric** Nonspherical surface, usually symmetrical about its axis of rotation and derived from conic sections (therefore having both apical radius and eccentricity); possibly front, back, or peripheral surfaces of a contact lens.

**Astigmatism** Refractive anomaly due to unequal refraction of light in different meridians of the eye, generally caused by a toroidal anterior surface of the cornea.

**Atopic dermatitis** Allergic inflammation of the skin.

**Back optical diameter (or zone)** The central optical posterior surface of the contact lens.

**Back toric lens** A contact lens which has a back surface cylinder and spherical front surface for toric cornea fitting.
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**Base curve, or back central optic radius (r or BCOR)**  The radius of curvature of the posterior central optical portion, in the area corresponding to the optical zone, of a contact lens, usually measured in millimeters.

**Bifocal**  Pertaining to a lens system having two focal lengths.

**Binding**  A condition in which contact lenses (particularly rigid CLs which position inferiorally) occasionally cease to move and become adherent to the underlying cornea; removal of the CLs reveals areas where the back surface (optic zone and edge) of the contact lens has become compressed into the underlying tissues, leaving a mold of its shape.

**Bitoric lens**  A rigid contact lens with astigmatic (toric or cylindrical) anterior and posterior surfaces.

**Blepharitis**  An inflammatory process affecting the lid margins, the lash follicles, or the openings of the meibomian glands.

**Carrier**  A radially symmetrical portion of a lenticular design contact lens, peripheral to the optical cap. The carrier may be negative (edge thickness greater than the junction thickness), positive (edge thickness less than that of the junction), or parallel in cross-section.

**Central circular clouding (CCC)**  A superficial diffuse edema of the cornea, usually circular, and associated with the wearing of contact lenses which either bear on the central epithelium or entrap tear fluid in this area; central corneal clouding.

**CN bevel**  Slanted thinning of a contact lens edge on its anterior surface, to reduce edge thickness.

**Contact lens (CL)**  A small, shell-like, bowl-shaped glass or plastic lens that rests directly on the eye, in contact with the cornea or the sclera or both, serving as a new anterior surface of the eye and/or as a retainer for fluid between the cornea and the contact lens, ordinarily to correct for refractive errors of the eyes.

**Continuous wear**  Wearing a contact lens constantly, only removing it when a complication is encountered.

**Corneal CL**  A contact lens worn on the cornea, typically 7.5 to 11.5 mm in total diameter.

**Corneal exhaustion syndrome (CES)**  An acute intolerance to contact lens wear in previously successful wearers, usually believed to be associated with corneal swelling (edema), changes in endothelial cell morphology, and visual difficulties.

**D**  Diffusion coefficient from the engineering literature (see Dk and Dk/t); also diopter, a unit of optical power.

**Daily wear lens**  A contact lens requiring daily or more frequent removal for cleaning and other purposes.

**Dellen**  Transient ellipsoid depressions in the cornea caused by localized severe dehydration, usually involving acute shrinkage of the stroma without any loss of epithelium.

**Dendrite**  A branch-like formation in the corneal epithelium, usually seen with the aid of sodium fluorescein solution; the hallmark sign of herpetic keratitis.

**Dimple veil stain**  Depressions in corneal epithelial surface from bubbles trapped between a contact lens and the corneal surface; usually associated with a somewhat “tight” or “steep” RGP or HCL, or to a related corneal depression (e.g., in keratoconus, or associated with a scarred cornea).

**Edematous corneal formation (ECF)**  Epithelial dendritic figure related to rigid (especially PMMA) contact lens-generated edema of the corneal epithelium.
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**Edge lift**  The distance between an extension of the BCOR and the absolute edge of the lens; when measured parallel to the optical axis, axial edge lift (AEL); when measured along the radius, radial edge lift (REL).

**Equilibration**  A time period during which a contact lens comes into a form of steady state with the properties of the patient’s tear layer, relating to its tonicity, pH, etc.

**Extended wear lens**  A contact lens designed of such oxygen permeability, thickness, and periodic cleaning requirements and prescribed for a person of compatible physiological characteristics as to permit continuous wear for more than a day.

**Fenestration**  A perforation to allow transfer of air and/or tears between the contact lens and cornea.

**Filtering bleb**  A conjunctival vesicle with a scleral channel allowing direct communication of fluid from the inside of the eye, either planned (e.g., for treatment of glaucoma) or unplanned, (e.g., following cataract extraction).

**Follicle**  Conjunctival nodule of lymphatic origin, lacking a central vascular core; seen in viral, chlyamdial, allergic conjunctivitis.

**Front optic diameter (or zone)**  The anterior optical surface of a contact lens.

**Front surface toric lens (FST)**  Contact lens with toric optics on only its front surface and a spherical base curve, intended to correct residual astigmatism.

**Giant papillary conjunctivitis (GPC)**  Type I atopic response in the palpebral conjunctiva, in which the breakdown of septae between many small papillae create giant (>1 mm) papillae.

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**Haptic CL**  Any contact lens having a section designed to rest on the sclera.

**Horizontal visible iris diameter (HVID)**  The diameter of the cornea as measured across the visible limbus horizontally, usually measured in millimeters.

**Hydrogel**  Any of a family of water-absorbing (hydrophilic) plastics used for contact lenses; also called soft lenses.

**Hydroxethylmethacrylate (HEMA)**  The first plastic used for a hydrogel lens, invented by Otto Wichterle.

**Hypermetropia (hyperopia)**  A refractive condition in which the light entering the nonaccommodated eye is focused behind the retina; farsightedness.

**Infiltrates**  White or gray material in the normally transparent cornea, usually composed of either inflammatory leukocytes or invading microorganisms, or both.

**K**  Symbol for the central corneal curvature of longest radius, as measured by a keratometer.

**k**  Solubility (of oxygen) in a material (e.g., plastic), from the engineering literature (see Dk and Dk/t).

**Keratoconus**  A developmental or dystrophic deformity of the cornea in which it becomes cone-shaped, due to a thinning and stretching of the tissue in its central area. It usually manifests itself during puberty and is usually bilateral but asymmetric.

**Keratometry**  Measurement of the anterior curve of the cornea.

**Lenticular design**  A (contact) lens design with a front optic diameter smaller than the lens total diameter, creating an optical “cap” and a peripheral carrier portion.
Microcystic edema (MCE) Very small fluid cysts in the corneal epithelium.

Monovision A technique for the optical correction of presbyopia, by which a binocular patient is deliberately provided with one contact lens prescribed for distance vision and the other for near vision.

Myopia Refractive condition in which the light entering the nonaccommodated eye is focused in front of the retina; nearsightedness.

Neovascularization (NV) Growth of abnormal new blood vessels.

Neurotrophic keratitis Corneal epitheliopathy due to damaged innervation.

Nonsteroidal anti-inflammatory drug (NSAID) Any of several classes of pharmaceutical agents, excluding steroids, that act to suppress the inflammatory response.

Ocular rosacea Acne rosacea involving the eye or its adnexa, that may include any or all of these chronic eye signs: blepharitis, meibomitis, telangiectasia of the lids; insufficient tears; bulbar and corneal epitheliopathies, corneal scarring and melting.

Optic cap See lenticular design.

Orthokeratology The science or program of therapeutic application of contact lenses to alter the curvature of the cornea, especially to reduce myopia.

Pannus An abnormal, superficial vascularization of the cornea associated with a membranouslike infiltration of granulation tissue.

Papilla Allergically induced conjunctival nodule with a central vascular core; collection of mast cells, basophils, and eosinophils, and subsequent other inflammatory cells; see giant papillary conjunctivitis.

Penetrating keratoplasty (PKP) A surgical procedure in which a section of the entire thickness of an opaque cornea is removed and replaced by transparent cornea.

Permeability Oxygen permeability of a plastic, called “Dk” from the engineering literature.

Peripheral curves Nonoptical curves on both anterior and posterior peripheral surfaces of contact lenses, of set chord lengths and curvatures.

Piggyback A contact lens system in which a soft CL is used underneath a rigid CL on the same eye.

Polymegethism Marked pleomorphism (cell size variation) in the corneal endothelial layer.

Polymethyl methacrylate (PMMA) A lightweight, transparent, essentially non-oxygen-permeable thermoplastic used in the manufacture of contact lenses; lucite or plexiglas.

Posterior apical radius of curvature (PAR) The radius of curvature over a small area surrounding the apex of the posterior surface of an aspheric contact lens.

Presbyopia A reduction in accommodative ability that occurs normally with age and necessitates a plus lens addition for satisfactory near vision.

Prism A triangular refracting body that optically deflects light toward its base while separating wavelengths; due to its shape, one side is therefore of greater thickness and mass than the other.

Prosthetic device Artificial body part.

Pseudodendrite Epithelial branch-like formation not associated with herpetic keratitis; usually a contact lens solution related hypersensitivity or hypoxic response.
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**Pterygium** A horizontal, triangular growth of the bulbar conjunctiva occupying the intrapalpebral tissue, with the apex extending onto the cornea.

**Ptosis** Drooping of the upper eyelid below its normal position.

**Rigid gas permeable (RGP) lens** Any of a family of rigid oxygen-permeable plastics that retain their form without support, under normal conditions; these plastics have been prepared for the contact lens industry to allow oxygen diffusion at clinically significant levels; also called hard gas permeable (HGP) and “semi-soft lens.”

**Scleral (or haptic) contact lens** A large contact lens, covering most of the front of the eye, including the bulbar conjunctiva as well as the cornea.

**Soft lenses** A contact lens made of a water-absorbing substance which, when worn, is soft and flexible.

**Spherical** Round; nonastigmatic; nonaspheric.

**Stromal striae** Fine parallel lines seen in the deep stroma during corneal swelling from contact lens-associated hypoxia, early Fuchs dystrophy, or keratoconus. (Deeper frank folds in Descemet’s membrane usually are not related to contact lens wear and are called “striate keratopathy”).

**Superior epithelial arcuate lesion (SEAL)** Lesion of unknown etiology that occurs occasionally during hydrogel contact lens wear; also called “epithelial splitting.” The eye is asymptomatic, or mildly symptomatic, and an arc of corneal epithelial disruption approximately 1 mm below and parallel to the superior limbus is evident.

**Thickness (t)** Thickness of a contact lens, usually in millimeters and usually measured at the center of the lens.

**Toric lens** A lens which has one surface with two meridians of curvature, least and greatest curvatures, located at right angles to each other; astigmatism.

**Total diameter (TD)** The chord diameter of a contact lens, measured from one absolute edge to the other in millimeters.

**Transmissibility** The ability of a contact lens material to diffuse oxygen; oxygen permeability divided by thickness, expressed as “Dk/t.”

**Truncation** Deliberate removal and polishing of a portion of a circular contact lens circumference, to affect lens rotation and positioning.

**Vascularized limbal keratitis (VLK)** Inflammation at the lateral borders of the cornea, initiated by desiccation from rigid contact lens wear resulting in a pseudopterygium.

**Water content (WC)** Percentage of water in a hydrogel material.

**“3/9” staining** Corneal epithelial erosions at the lateral borders of the cornea, initiated by desiccation from rigid contact lens wear, close to the positions occupied by 3 o’clock and 9 o’clock on an analog watch dial.

Sources:


