Bacterial Keratitis
Limited Revision
As a service to its members and the public, the American Academy of Ophthalmology has developed a series of clinical practice guidelines called Preferred Practice Patterns that identify characteristics and components of quality eye care. Appendix 1 describes the core criteria of quality eye care.

The Preferred Practice Pattern® (PPP) guidelines are based on the best available scientific data as interpreted by panels of knowledgeable health professionals. In some instances, such as when results of carefully conducted clinical trials are available, the data are particularly persuasive and provide clear guidance. In other instances, the panels have to rely on their collective judgment and evaluation of available evidence.

Preferred Practice Pattern guidelines provide the pattern of practice, not the care of a particular individual. While they should generally meet the needs of most patients, they cannot possibly best meet the needs of all patients. Adherence to these PPPs will not ensure a successful outcome in every situation. These practice patterns should not be deemed inclusive of all proper methods of care or exclusive of other methods of care reasonably directed at obtaining the best results. It may be necessary to approach different patients’ needs in different ways. The physician must make the ultimate judgment about the propriety of the care of a particular patient in light of all of the circumstances presented by that patient. The American Academy of Ophthalmology is available to assist members in resolving ethical dilemmas that arise in the course of ophthalmic practice.

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Innovation in medicine is essential to assure the future health of the American public, and the Academy encourages the development of new diagnostic and therapeutic methods that will improve eye care. It is essential to recognize that true medical excellence is achieved only when the patients’ needs are the foremost consideration.

All PPPs are reviewed by their parent panel annually or earlier if developments warrant and updated accordingly. To ensure that all PPPs are current, each is valid for 5 years from the “approved by” date unless superseded by a revision. Preferred Practice Pattern guidelines are funded by the Academy without commercial support. Authors and reviewers of PPPs are volunteers and do not receive any financial compensation for their contributions to the documents. The PPPs are externally reviewed by experts and stakeholders before publication.

The intended users of the Bacterial Keratitis Preferred Practice Pattern guideline are ophthalmologists.
FINANCIAL DISCLOSURES

In compliance with the Council of Medical Specialty Societies’ Code for Interactions with Companies (available at [www.cmss.org/codeforinteractions.aspx](http://www.cmss.org/codeforinteractions.aspx)), relevant relationships with industry occurring from January 2011 to September 2011 are listed. The Academy has Relationship with Industry Procedures to comply with the Code (available at [http://one.aao.org/CE/PracticeGuidelines/ppp.aspx](http://one.aao.org/CE/PracticeGuidelines/ppp.aspx)).

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INTRODUCTION

The Preferred Practice Pattern® (PPP) guidelines have been written on the basis of three principles.

- Each Preferred Practice Pattern should be clinically relevant and specific enough to provide useful information to practitioners.
- Each recommendation that is made should be given an explicit rating that shows its importance to the care process.
- Each recommendation should be given an explicit rating that shows the strength of evidence that supports the recommendation and reflects the best evidence available.

In the process of revising this document, a detailed literature search of PubMed and the Cochrane Library for articles in the English language was conducted in December 2007 on the subject of bacterial keratitis for the years 2005 to 2007. To complete this limited revision, PubMed and the Cochrane Library were searched on February 1, 3, and 11, 2011 on the subject of bacterial keratitis, limited to English language and from publication date of 2008 to the date of the search. Details of the literature search are available at www.aao.org/ppp. The results were reviewed by the Cornea/External Disease Panel and used to prepare the recommendations, which they rated in two ways.

The panel first rated each recommendation according to its importance to the care process. This “importance to the care process” rating represents care that the panel thought would improve the quality of the patient’s care in a meaningful way. The ratings of importance are divided into three levels.

- Level A, defined as most important
- Level B, defined as moderately important
- Level C, defined as relevant but not critical

The panel also rated each recommendation on the strength of evidence in the available literature to support the recommendation made. The “ratings of strength of evidence” also are divided into three levels.

- Level I includes evidence obtained from at least one properly conducted, well-designed randomized controlled trial. It could include meta-analyses of randomized controlled trials.
- Level II includes evidence obtained from the following:
  - Well-designed controlled trials without randomization
  - Well-designed cohort or case-control analytic studies, preferably from more than one center
  - Multiple-time series with or without the intervention
- Level III includes evidence obtained from one of the following:
  - Descriptive studies
  - Case reports
  - Reports of expert committees/organization (e.g., PPP Panel consensus with external peer review)

The evidence cited is that which supports the value of the recommendation as something that should be performed to improve the quality of care. The panel believes that it is important to make available the strength of the evidence underlying the recommendation. In this way, readers can appreciate the degree of importance the panel attached to each recommendation and they can understand what type of evidence supports the recommendation.

The ratings of importance and the ratings of strength of evidence are given in bracketed superscripts after each recommendation. For instance, “[A:II]” indicates a recommendation with high importance to clinical care [A], supported by sufficiently rigorous published evidence, though not by a randomized controlled trial [II].

The sections entitled Orientation and Background do not include recommendations; rather they are designed to educate and provide summary background information and rationale for the recommendations that are presented in the Care Process section. A summary of the major recommendations for care is included in Appendix 2.
ORIENTATION

ENTITY
Bacterial keratitis, which includes entities with the following ICD-9 classifications:
- Corneal ulcer (370.0)
- Corneal ulcer, unspecified (370.00)
- Marginal corneal ulcer (370.01)
- Ring corneal ulcer (370.02)
- Central corneal ulcer (370.03)
- Hypopyon ulcer (370.04)
- Perforated corneal ulcer (370.06)
- Corneal abscess (370.55)
- Corneal infiltrate (371.20)

DISEASE DEFINITION
Bacterial keratitis is an infectious disease of the cornea caused by bacteria.

PATIENT POPULATION
Individuals of all ages who present with symptoms and signs suggestive of bacterial keratitis such as pain, redness, blurred vision, discharge, corneal infiltrates, ulcerations, and anterior chamber inflammation.

ACTIVITY
Diagnosis and management of the patient with bacterial infection of the cornea.

PURPOSE
The purpose of diagnosis and management of patients with bacterial keratitis is to minimize visual loss, relieve pain, eliminate the infectious agent, and minimize structural damage to the cornea.

GOALS
- Recognize and reduce risk factors that predispose patients to bacterial infection of the cornea
- Establish the diagnosis of bacterial keratitis, differentiating it from other causes of keratitis
- Utilize appropriate diagnostic tests
- Select appropriate therapy
- Relieve pain
- Establish appropriate follow-up
- Prevent complications such as medication toxicity, intraocular infection, cataract, corneal perforation, and loss of vision
- Educate patients and their families about treatment and ways to reduce risk factors in the future

BACKGROUND

EPIDEMIOLOGY
It is estimated that 30,000 cases of microbial keratitis (including bacteria, fungus, and Acanthamoeba) occur annually in the United States. Bacterial keratitis rarely occurs in the normal eye because of the human cornea's natural resistance to infection. However, predisposing factors including contact lens wear, trauma, corneal surgery, ocular surface disease (e.g., tear deficiencies and corneal abnormalities), systemic diseases, and immunosuppression may alter the defense mechanisms of the ocular surface and permit bacteria to invade the cornea (see Risk Factors).
Causes of bacterial keratitis in the United States are listed in Table 1. The most common pathogenic organisms identified in bacterial keratitis include Staphylococci and gram-negative rods (Pseudomonas species). Studies differ on the epidemiology of bacterial keratitis. A review of 5 years of bacterial isolates from 1999 to 2004 from cases of bacterial keratitis in Brisbane, Australia, showed changes in the yearly frequency of bacterial groups, but these were not statistically significant. In bacterial keratitis associated with the use of contact lenses, Pseudomonas has been identified as the most frequent etiologic agent, accounting for up to one-third of cases. However, a review from Florida found that Serratia marcescens was isolated as frequently as Pseudomonas aeruginosa in contact lens-associated keratitis and a review from Melbourne, Australia, found that Pseudomonas was isolated in only 7% of contact-lens-associated keratitis. One study found that 78.2% of cultures grew a gram-positive organism while 20.2% grew a gram-negative organism. Of the gram-positive organisms, 40.8% were coagulase negative Staphylococci and 11.5% were Staphylococcus aureus. A review of the gram-negative organisms revealed Moraxella (8.0%) and Pseudomonas aeruginosa (3.4%) as the most common organisms. Another ten-year review revealed the most common isolated bacteria was Staphylococci (40.1%), followed by Pseudomonas species (28.5%), other gram-negative species (17.2%), Streptococci (7.1%), and Corynebacteria (6.0%). Two retrospective analyses from the United Kingdom and Italy revealed contact lens use as the most common risk factor for bacterial keratitis. Gram-positive organisms were the most common organisms in the UK study while Pseudomonas was the most commonly identified organism in the study from Italy. A Brazilian study of the elderly also identified gram-positive organisms as the most common pathogen (75.5%) and Pseudomonas as the most common among the gram-negative pathogen. A preponderance of gram-positive organisms (63.4%) vs. gram-negative organisms (36.6%) was also identified in another study where Staphylococcus epidermidis and Corynebacterium were the most commonly identified gram-positive organisms. In this study, Pseudomonas was the most common gram-negative organisms. Lastly, mixed microbial keratitis can occur. The most common causative organisms are Staphylococcus epidermidis and Fusarium species. In these patients, the most common etiology is trauma.

<table>
<thead>
<tr>
<th>Class/Organism</th>
<th>Common Isolates*</th>
<th>Cases (%)</th>
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<tbody>
<tr>
<td>Gram-Positive Isolates</td>
<td></td>
<td>29–53</td>
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<tr>
<td>Gram-positive Cocci</td>
<td>Staphylococcus aureus</td>
<td>4–19</td>
</tr>
<tr>
<td></td>
<td>Coagulase negative Staphylococci</td>
<td>1–45.5</td>
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<tr>
<td></td>
<td>Streptococcus pneumoniae</td>
<td>0–3</td>
</tr>
<tr>
<td></td>
<td>Streptococcus viridans group</td>
<td>1–6</td>
</tr>
<tr>
<td>Gram-positive Bacilli</td>
<td>Propionibacterium species</td>
<td>4–7</td>
</tr>
<tr>
<td></td>
<td>Mycobacterium species</td>
<td>3</td>
</tr>
<tr>
<td>Gram-Negative Isolates</td>
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<td>47–50</td>
</tr>
<tr>
<td>Gram-negative Bacilli</td>
<td>Pseudomonas aeruginosa</td>
<td>3–33</td>
</tr>
<tr>
<td></td>
<td>Serratia marcescens</td>
<td>3–13.5</td>
</tr>
<tr>
<td></td>
<td>Proteus mirabilis</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Moraxella species and related</td>
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</tr>
<tr>
<td></td>
<td>Enteric gram-negative bacilli,</td>
<td>1–10</td>
</tr>
<tr>
<td></td>
<td>other</td>
<td></td>
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</tbody>
</table>

* Regional differences may affect the order and percentage of pathogens.

Ranges are from the following sources:

RISK FACTORS
Risk factors that predispose patients to bacterial keratitis can be divided into four categories.

Extrinsic Factors

- Use of contact lenses, especially with the following:
  - Overnight wear\(^2\),\(^5\),\(^27\)
  - Overnight orthokeratology\(^28\)-\(^32\)
  - Misuse (overwear)
  - Inadequate disinfection of contact lenses
  - Contamination of the contact lens storage case\(^27\)
  - Ineffective or contaminated contact lens solution
- Trauma, including chemical and thermal injuries, foreign bodies, and local irradiation
- Previous ocular and eyelid surgery, especially corneal surgery, including refractive surgery and penetrating keratoplasty
- Loose sutures\(^33\)
- Medication-related factors (e.g., contaminated ocular medications, topical nonsteroidal anti-inflammatory drugs, anesthetics, corticosteroids, preservatives, glaucoma medications)
- Immunosuppression (topical and systemic)
- Factitious disease, including anesthetic abuse
- Substance abuse (crack cocaine)

Ocular Surface Disease

- Tear-film deficiencies
- Abnormalities of the eyelid anatomy and function (including exposure)
- Misdirection of eyelashes
- Adjacent infection (conjunctivitis, including gonococcal, blepharitis, canaliculitis, dacryocystitis)

Corneal Epithelial Abnormalities

- Neurotrophic keratopathy (e.g., trigeminal neuropathy, herpes keratitis)
- Disorders predisposing to recurrent erosion of the cornea
- Corneal abrasion or epithelial defect
- Viral keratitis (herpes simplex virus or varicella zoster virus keratitis)
- Corneal epithelial edema, especially bullous keratopathy

Systemic Conditions

- Diabetes mellitus
- Debilitating illness, especially malnourishment and/or respirator dependence
- Collagen vascular disease
- Dermatological/mucous membrane disorders (e.g., Stevens-Johnson syndrome, ocular mucous membrane pemphigoid)
- Immunocompromised status
- Atopic dermatitis/blepharoconjunctivitis
- Gonococcal infection with conjunctivitis
- Vitamin A deficiency
- Acoustic neuroma or neurological surgery causing damage to the Vth or VIIth cranial nerves

NATURAL HISTORY
While some forms of bacterial keratitis may not result in visual loss, many are associated with subsequent loss of vision due to corneal scarring or topographic irregularity. Untreated or severe bacterial keratitis may result in corneal perforation and has the potential to develop into endophthalmitis and result in loss of the eye. Because this process of destruction can take place rapidly (within 24 hours when the infection is caused by a virulent organism), optimal management
requires rapid recognition, timely institution of therapy, and appropriate follow-up. Bacterial keratitis can occur in any part of the cornea, but infections involving the central or paracentral cornea are of paramount importance. Scarring in this location has the potential to cause substantial visual loss, even if the infecting organism is successfully eradicated. While some bacteria (e.g., gonococcus) can invade an intact corneal epithelium, most cases of bacterial keratitis develop at the site of an abnormality or defect in the corneal surface.

The rate of disease progression is dependent on the virulence of the infecting organism and on host factors (see Risk Factors, and Prevention and Early Detection). For example, highly virulent organisms such as *Pseudomonas*, *Streptococcus pneumoniae*, or gonococcus cause rapid tissue destruction, while other organisms such as nontuberculous mycobacteria and *Streptococcus viridans* species are usually associated with a more indolent course. Some bacteria that are considered to be normal conjunctival flora (e.g., *Corynebacterium*) may become opportunistic pathogens in the compromised eye.

**PREVENTION AND EARLY DETECTION**

Avoiding or correcting predisposing factors may reduce the risk of bacterial keratitis. For example, screening patients for predisposing factors and educating them about the risks of overnight wear of contact lenses and proper contact lens care may reduce the incidence of bacterial keratitis in those who wear contact lenses. (See Appendix 3 for recommendations for contact lens care.) Most ocular trauma can be avoided by using protective eyewear for sports and other high-risk activities.

Early detection and appropriate treatment are important to minimize permanent visual loss. Patients with risk factors predisposing them to bacterial keratitis should be educated about their relative risk, be acquainted with the signs and symptoms of infection, and be informed that they should consult an ophthalmologist promptly if they experience such warning signs or symptoms. Ocular surface disease such as corneal epithelial defects, severe tear deficiency, or lagophthalmos should be treated. Prophylactic antibiotics can be considered for patients with chronic epithelial defects; however, the routine use of prophylactic topical antibiotics in this setting is controversial, because their efficacy has not been established and chronic use may promote growth of resistant organisms. Prophylactic topical antibiotics following corneal abrasion may prevent ulceration when treatment is started within 24 hours of the abrasion.

**CARE PROCESS**

**PATIENT OUTCOME CRITERIA**

Outcome criteria for treating bacterial keratitis include the following:

- Resolving corneal inflammation
- Reducing pain
- Resolving infection/infiltrate
- Restoring corneal integrity and minimizing scarring and vascularization
- Restoring visual function

**DIAGNOSIS**

Evaluation of the patient with presumed bacterial keratitis includes those features of the comprehensive medical eye evaluation specifically relevant to bacterial keratitis, as listed below.
History

Obtaining a detailed history is important in evaluating patients with bacterial keratitis. Pertinent information includes the following:

- Ocular symptoms: e.g., degree of pain, redness, discharge, blurred vision, photophobia, duration of symptoms, circumstances surrounding the onset of symptoms
- Contact lens history: e.g., wearing schedule, overnight wear, type of contact lens, contact lens solution, contact lens hygiene protocol, tap-water rinse of contact lenses, swimming, using a hot tub, or showering while wearing contact lenses
- Review of other ocular history, including risk factors such as herpes simplex virus keratitis, varicella zoster virus keratitis, previous bacterial keratitis, trauma, dry eye, and previous ocular surgery, including refractive surgery
- Review of other medical problems and systemic medications
- Current and recently used ocular medications
- Medication allergies

Examination

The physical examination includes measurement of visual acuity, an external examination, and slit-lamp biomicroscopy.

Visual Acuity

In many cases, patient discomfort, tearing, and inflammation will compromise visual acuity. It is useful, however, to document baseline visual acuity and to ascertain that it is consistent with the anterior segment examination.

External Examination

An external examination should be performed with particular attention to the following:

- General appearance of the patient, including skin conditions
- Facial examination
- Globe position
- Eyelids and eyelid closure
- Conjunctiva
- Nasolacrimal apparatus
- Corneal sensation

Slit-Lamp Biomicroscopy

Clinical features suggestive of bacterial keratitis include suppurative stromal infiltrate (particularly those greater than 1 mm in size) with indistinct edges, edema, and white cell infiltration in surrounding stroma. An epithelial defect is typically present. An anterior chamber reaction is often seen.

Slit-lamp biomicroscopy should include evaluation of the following:

- Eyelid margins
  - Inflammation
  - Ulceration
  - Eyelash abnormalities including trichiasis/distichiasis
  - Irregularities
  - Lacrimal punctal anomalies
  - Ectropion/entropion
- Conjunctiva
  - Discharge
  - Inflammation
  - Morphologic alterations (e.g., follicles, papillae, cicatization, keratinization, membrane, pseudomembrane, ulceration, prior surgery)
  - Ischemia
  - Foreign body
  - Filtering bleb
- Sclera
  - Inflammation (e.g., infectious versus autoimmune)
  - Ulceration
  - Scarring/thinning
  - Nodule
  - Ischemia
- Cornea
  - Epithelium, including defects and punctate keratopathy, edema
  - Stroma, including ulceration, thinning, perforation, and infiltrate (location [central, peripheral, perineural, surgical, or traumatic wound], density, size, shape [ring], number [satellite], depth, character of infiltrate margin [suppuration, necrosis, feathery, soft, crystalline], color), edema
  - Endothelium
  - Foreign body, including sutures
  - Signs of corneal dystrophies (e.g., epithelial basement membrane dystrophy)
  - Previous corneal inflammation (thinning, scarring, or neovascularization)
  - Signs of previous corneal or refractive surgery
- Anterior chamber
  - For depth and the presence of inflammation, including cell and flare, hypopyon, fibrin, hyphema
- Anterior vitreous
  - For the presence of inflammation
- Contralateral eye for clues to etiology as well as possible similar pathology

**Diagnostic Tests**

**Cultures and Smears**

The majority of community-acquired cases of bacterial keratitis resolve with empiric therapy and are managed without smears or cultures. Smears and cultures are indicated, however, in cases that involve a corneal infiltrate that is large and extends to the middle to deep stroma; that are chronic in nature or unresponsive to broad spectrum antibiotic therapy; or that have atypical clinical features suggestive of fungal, amoebic, or mycobacterial keratitis. Smears and cultures are often helpful in eyes that have an unusual history, e.g., if there has been trauma with vegetable matter or if the patient wore contact lenses while in a hot tub. Specialized studies may be indicated to identify atypical organisms. The hypopyon that occurs in eyes with bacterial keratitis is usually sterile, and aqueous or vitreous taps should not be performed unless there is a high suspicion of microbial endophthalmitis, such as following an intraocular surgery, perforating trauma, or sepsis. Before initiating antimicrobial therapy, cultures are indicated in sight-threatening or severe keratitis of suspected microbial origin.

A culture is a means of identifying the causative organism(s) and the only means of determining sensitivity to antibiotics. Cultures are helpful to guide modification of therapy in patients with a poor clinical response to treatment and to decrease toxicity by eliminating unnecessary medications. Microbial pathogens may be categorized by examining stained smears of corneal scrapings; this may increase yield of identification of the pathogen, especially if the patient is on antibacterial therapy. The material for smear is applied to clean glass microscope slides in an even, thin layer (see Appendix 4 for specific diagnostic stains). Polymerase chain reaction and immunodiagnostic techniques may be useful, but they are not widely available currently.

Corneal material is obtained by instilling a topical anesthetic agent and using a heat-sterilized platinum (Kimura) spatula, blade, jeweler’s forceps, or other similar sterile instrument to obtain scrapings of material from the advancing borders of the infected area of the cornea. Culture yield may be improved by avoiding anesthetics with preservatives. Obtaining only purulent material usually results in inadequate yield. A thiol or thioglycollate broth-moistened dacron/calcium alginate or sterile cotton swab may also be used to obtain material. This is most easily performed with slit-lamp biomicroscope magnification.
Corneal scrapings for culture should be inoculated directly onto appropriate culture media to maximize culture yield (see Appendix 5). If this is not feasible, specimens should be placed in transport media. In either case, cultures should be immediately incubated or taken promptly to the laboratory. Cultures of contact lenses, the lens case, and contact lens solution may provide additional information to guide therapy.

It may be helpful to obtain cultures from eyes treated empirically that were not first cultured and in which the clinical response is poor, although a delay in pathogen recovery may occur. If the cultures are negative, the ophthalmologist may consider stopping antibiotic treatment for 12 to 24 hours and then reculturing.

**Corneal Biopsy and Deep Stromal Culture Techniques**

Corneal biopsy may be indicated if there has been a lack of response to treatment or if cultures have been negative on more than one occasion and the clinical picture continues to strongly suggest an infectious process. It may also be indicated if the infiltrate is located in the mid or deep stroma with overlying uninvolved tissue. In a cooperative patient, corneal biopsy may be performed while at the slit-lamp biomicroscope or operating microscope. Using topical anesthesia, a small trephine (2 mm to 3 mm) or blade is used to excise a small piece of stromal tissue that is large enough to allow bisection so that one portion can be sent for culture and the other for histopathology. The biopsy specimen should be delivered to the laboratory in a timely fashion.

An option for a deep corneal abscess may be to use a suture that can be passed through the abscess without disturbing the overlying intact corneal epithelium and stroma. A 7-0 or 8-0 vicryl or silk suture can be passed through the abscess. The pathogen may attach to the fibers of the suture, and the suture can then be cultured. Another option in cases of a deep corneal abscess with overlying clear cornea is to take the biopsy from below a lamellar flap. An additional set of smears and cultures can be obtained from the deep stroma after the biopsy is performed.

**Corneal Imaging**

Scanning laser confocal microscopy is a relatively new technology used to image the various levels of the cornea from epithelium through stroma to the endothelium. Initially, confocal microscopy had been used to examine endothelial cells in vivo to assist clinicians in the management of endothelial conditions, as well as ex vivo to examine the quality of potential corneal donor tissue. With the recent advances in confocal technology to enhance the resolution and microscopic power, its use as a diagnostic tool has broadened. Confocal technology has been shown to be of some use in the diagnosis of infectious keratitis including bacterial, fungal and most notably, parasitic (i.e., Acanthamoeba).

**Differential Diagnosis**

The differential diagnosis includes infectious and noninfectious causes of infiltrates. Nonbacterial corneal pathogens, including fungi (both yeast and mold), parasites (including protozoa such as Acanthamoeba), and nematodes (such as Onchocerca) may cause infiltrative keratitis. An increase in the incidence of Acanthamoeba and fungal keratitis since 2004 has been noted. Viruses including herpes simplex virus, varicella zoster virus, and Epstein-Barr virus produce immunologically mediated corneal infiltrates that may resemble a bacterial, fungal, or acanthamoebal keratitis. Eyes with viral keratitis are also prone to microbial superinfection. When in doubt, it is often best initially to manage these cases as infected. Viruses can also cause a true suppurative keratitis without superinfection, as in necrotizing stromal disease.

Noninfectious stromal infiltration may be associated with contact lens wear (particularly extended-wear contact lenses) or antigens from local and systemic bacterial infections. Systemic diseases, such as collagen vascular disorders (e.g., rheumatoid arthritis, systemic lupus erythematosus), vasculitic disorders (e.g., polyarteritis nodosa, Wegener granulomatosis), and other inflammatory disorders such as sarcoidosis may produce infiltrative keratitis. Other causes include dermatologic disorders (e.g., severe ocular rosacea) and allergic conditions (e.g., vernal keratoconjunctivitis and atopic keratoconjunctivitis). Atopy is also a risk factor for herpes simplex ocular disease. Corneal trauma, including chemical and thermal injury, and corneal foreign bodies, including exposed or loose sutures, may also lead to infiltrative keratitis, which may be infectious or noninfectious.
Topical broad-spectrum antibiotics are used initially in the empiric treatment of bacterial keratitis.46 [A:III] (See Table 2 for recommendations about antibiotic therapy.) For central or severe keratitis (e.g., deep stromal involvement or an infiltrate larger than 2 mm with extensive suppuration), a loading dose (e.g., every 5 to 15 minutes for the first 30 to 60 minutes), followed by frequent applications (e.g., every 30 minutes to 1 hour around the clock), is recommended. [A:III] For less severe keratitis, a regimen with less frequent dosing is appropriate. Cycloplegic agents may be used to decrease synchia formation and to decrease pain in more severe cases of bacterial keratitis and are indicated when substantial anterior chamber inflammation is present.

Single-drug therapy using a fluoroquinolone has been shown to be as effective as combination therapy utilizing antibiotics that are fortified by increasing their concentration over commercially available topical antibiotics.79-81 Ciprofloxacin 0.3%, ofloxacin 0.3% and, more recently, levofloxacin 1.5% have been approved by the Federal Drug Administration for the treatment of bacterial keratitis.82-84 Compared with ofloxacin 0.3%, levofloxacin 1.5% demonstrated equal efficacy in the endpoints of complete re-epithelialization and no progression of infiltrate for two consecutive visits.84 Some pathogens (e.g., Streptococci, anaerobes) reportedly have variable susceptibility to fluoroquinolones,80,85-89 and the prevalence of resistance to the fluoroquinolones appears to be increasing.6,86,90,91 Gatifloxacin and moxifloxacin have been reported to have better coverage of gram-positive pathogens than earlier generation fluoroquinolones in head-to-head in vitro studies.82 While widely used, the fourth-generation fluoroquinolones are not FDA-approved for the treatment of bacterial keratitis. However, in randomized controlled trials, both moxifloxacin and gatifloxacin performed at least as well as standard therapy, fortified cefazolin/tobramycin combination therapy, and potentially better than an earlier generation fluoroquinolone, ciprofloxacin.79,93,96 Approved by the Food and Drug Administration in 2009 for bacterial conjunctivitis, besifloxacin 0.6% is a topical fluoroquinolone that has similar potency against ocular pathogenic bacteria as the fourth generation agents. (Morris TW, Haas W, Brunner LS, et al. Clinical efficacy of besifloxacin ophthalmic suspension; integrated microbiological results of 3 trials for topical treatment of bacterial conjunctivitis. Paper presented at: Association for Research in Vision and Ophthalmology [ARVO] Annual Meeting: May 3-7, 2009; Ft Lauderdale, FL.) Several industry-sponsored in vitro and in vivo rabbit studies have shown potential utility in the management of acute bacterial keratitis, however, to date, there are no case reports or clinical trials in the peer-reviewed literature showing efficacy for this off-label indication.97-99 Although there have been some concerns of increased risk of corneal perforation with fluoroquinolones in the treatment of severe bacterial keratitis compared with traditional fortified topical antibiotics (cefazolin and tobramycin),81,100 these reports are retrospective, not from randomized controlled trials, and will need confirmation in future studies.

Combination fortified-antibiotic therapy is an alternative to consider for severe infection and for eyes unresponsive to initial treatment.101,102 Treatment with more than one agent may be necessary for nontuberculous mycobacteria; infection with this pathogen has been reported in association with LASIK.102 Meticillin-resistant Staphylococcus aureus (MRSA) has been isolated with increasing frequency from patients with bacterial keratitis103 and has been reported following keratorefractive surgery.104 Fluoroquinolones are generally poorly effective against MRSA ocular isolates.105
Methicillin-resistant *Staphylococcus aureus* isolates generally are sensitive to vancomycin. (See Appendix 6 for instructions for preparing fortified topical antibiotics.)

Systemic antibiotics are rarely needed, but they may be considered in severe cases where the infectious process has extended to adjacent tissues (e.g., the sclera) or when there is impending or frank perforation of the cornea. Systemic therapy is necessary in cases of gonococcal keratitis. Frequency of re-evaluation of the patient with bacterial keratitis depends on the extent of disease, but severe cases (e.g., deep stromal involvement or larger than 2 mm with extensive suppuration) initially should be followed at least daily until stabilization or clinical improvement is documented.

### TABLE 2  ANTIBIOTIC THERAPY FOR BACTERIAL KERATITIS

<table>
<thead>
<tr>
<th>Organism</th>
<th>Antibiotic</th>
<th>Topical Concentration</th>
<th>Subconjunctival Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>No organism identified or multiple types of organisms</td>
<td>Cefazolin with Tobramycin or gentamicin or Fluoroquinolones*</td>
<td>50 mg/ml 9–14 mg/ml Various†</td>
<td>100 mg in 0.5 ml 20 mg in 0.5 ml Various†</td>
</tr>
<tr>
<td>Gram-positive cocci</td>
<td>Cefazolin</td>
<td>50 mg/ml</td>
<td>100 mg in 0.5 ml</td>
</tr>
<tr>
<td></td>
<td>Vancomycin‡</td>
<td>15–50 mg/ml</td>
<td>25 mg in 0.5 ml</td>
</tr>
<tr>
<td></td>
<td>Bacitracin‡</td>
<td>10,000 IU</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fluoroquinolones*</td>
<td>Various†</td>
<td></td>
</tr>
<tr>
<td>Gram-negative rods</td>
<td>Tobramycin or gentamicin</td>
<td>9–14 mg/ml</td>
<td>20 mg in 0.5 ml</td>
</tr>
<tr>
<td></td>
<td>Ceftazidime</td>
<td>50 mg/ml</td>
<td>100 mg in 0.5 ml</td>
</tr>
<tr>
<td></td>
<td>Fluoroquinolones</td>
<td>Various†</td>
<td></td>
</tr>
<tr>
<td>Gram-negative cocci</td>
<td>Ceftriaxone</td>
<td>50 mg/ml</td>
<td>100 mg in 0.5 ml</td>
</tr>
<tr>
<td></td>
<td>Ceftazidime</td>
<td>50 mg/ml</td>
<td>100 mg in 0.5 ml</td>
</tr>
<tr>
<td></td>
<td>Fluoroquinolones</td>
<td>Various†</td>
<td></td>
</tr>
<tr>
<td>Nontuberculous mycobacteria</td>
<td>Amikacin</td>
<td>20–40 mg/ml</td>
<td>20 mg in 0.5 ml</td>
</tr>
<tr>
<td></td>
<td>Clarithromycin</td>
<td>10 mg/ml</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Azithromycin§</td>
<td>10 mg/ml</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fluoroquinolones</td>
<td>Various†</td>
<td></td>
</tr>
<tr>
<td>Nocardia</td>
<td>Sulfacetamide</td>
<td>100 mg/ml</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Amikacin</td>
<td>20–40 mg/ml</td>
<td>20 mg in 0.5 ml</td>
</tr>
<tr>
<td></td>
<td>Trimethoprim/sulfamethoxazole:</td>
<td>16 mg/ml</td>
<td></td>
</tr>
<tr>
<td></td>
<td>trimethoprim</td>
<td>80 mg/ml</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sulfamethoxazole</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Fewer gram-positive cocci are resistant to gatifloxacin and moxifloxacin than other fluoroquinolones.

† Besifloxacin 6 mg/ml; ciprofloxacin 3 mg/ml; gatifloxacin 3 mg/ml; levofloxacin 15 mg/ml; moxifloxacin 5 mg/ml; ofloxacin 3 mg/ml, all commercially available at these concentrations.

‡ For resistant *Enterococcus* and *Staphylococcus* species and penicillin allergy. Vancomycin and bacitracin have no gram-negative activity and should not be used as a single agent in empirically treating bacterial keratitis.

§ Systemic therapy is necessary for suspected gonococcal infection.


Modification of Therapy

The efficacy of the therapeutic regimen is judged primarily by the clinical response. The results of cultures and sensitivity testing may have an impact on therapeutic decision making, especially if the patient is not responding to initial therapy. If the patient is improving, however, therapy need not be adjusted solely on the basis of laboratory studies. Dual antibiotic treatment designed to achieve broad-spectrum coverage may become unnecessary once the causative organism has been isolated.

In general, the initial therapeutic regimen should be modified when the eye shows a lack of improvement or stabilization within 48 hours.[A:III] Keratitis due to Pseudomonas and other gram-negative organisms may exhibit increased inflammation during the first 24 to 48 hours despite appropriate therapy. Several clinical features suggest a positive response to antibiotic therapy:107

- Reduced pain
- Reduced amount of discharge
- Lessened eyelid edema or conjunctival injection
- Consolidation and sharper demarcation of the perimeter of the stromal infiltrate
- Decreased density of the stromal infiltrate in the absence of progressive stromal loss
- Reduced stromal edema and endothelial inflammatory plaque
- Reduced anterior chamber cells, fibrin, or hypopyon
- Initial re-epithelialization
- Cessation of progressive corneal thinning

Modification of therapy may mean a change in the type, concentration, or frequency of antibiotic treatment.

Topical therapy is tapered according to clinical response, taking into account the severity of the initial clinical picture and the virulence of the pathogen. Specific tapering recommendations are difficult to make, due to wide variability in the severity of the infectious process in individual cases. Because prolonged use of topical antibiotics causes toxicity, they should be tapered as the infection improves. Medication toxicity can cause worsening inflammation or even corneal melting. If there is a persistent epithelial defect and the infection is under control, adjunctive therapies to rehabilitate the surface should be instituted,[A:III] such as lubrication, antibiotic ointment, bandage contact lens, or tarsorrhaphy. More prolonged therapy may be mandated by the presence of virulent or indolent organisms or for immunocompromised patients. Most antibiotic eye drops should not be tapered below three to four times a day,[A:III] because low doses are subtherapeutic and may increase the risk of antibiotic resistance developing.

Indications for Reculture

Lack of a favorable clinical response, particularly in the setting of negative culture results, suggests the need for reculture and/or biopsy. Toxicity from medications or corticosteroid withdrawal may be confused with antibiotic failure, and medicamentosa may be a potential cause of an apparent lack of clinical improvement. Discontinuation of antibiotics for 12 to 24 hours prior to reculture may increase culture yield, as may avoidance of preserved solutions, such as anesthetic or cycloplegic agents. Selected media capable of supporting the growth of atypical microorganisms may also increase culture yield and can be considered, such as Löwenstein-Jensen media for atypical mycobacteria. (See Appendix 5 for a list of culture media for bacterial keratitis.) Other atypical organisms to consider are fungal or parasitic, such as Fusarium and Acanthamoeba. Fusarium and Acanthamoeba are of particular concern because of a rise in the incidence of keratitis due to these pathogens. Although these infections can be diagnosed using appropriate staining of corneal smears, confocal microscopy can also be helpful in identifying the organisms in the tissue.

Corticosteroid Therapy

Topical corticosteroid therapy may have a beneficial role in treating some cases of infectious keratitis. The potential advantage is the probable suppression of inflammation, which may reduce subsequent corneal scarring and associated visual loss. Potential disadvantages include recrudescence of infection, local immunosuppression, inhibition of collagen synthesis predisposing to corneal melting, and increased intraocular pressure. There is no conclusive scientific evidence indicating that corticosteroids alter clinical outcome.108-110 However, there is an ongoing clinical trial
comparing visual outcome, rate of epithelialization and infiltrate resolution with and without routine topical corticosteroid use in the management of bacterial keratitis. Despite the risks involved, many experts believe that the judicious use of topical corticosteroids can reduce morbidity. Patients being treated with ocular topical corticosteroids at the time of presentation of suspected bacterial keratitis should have their corticosteroid regimen reduced or eliminated until the infection has been controlled. Inflammation may temporarily increase as corticosteroids are reduced. The objective in topical corticosteroid therapy is to use the minimum amount of corticosteroid required to achieve control of inflammation. Successful treatment requires optimal timing, careful dose regulation, use of adequate concomitant antibacterial medication, and close follow-up. Corticosteroids should not be part of initial treatment of presumed bacterial ulcers, and ideally they should not be used until the organism has been determined by cultures. The use of corticosteroids in the initial treatment of corneal ulcers has been determined to be a risk factor for requiring a penetrating keratoplasty. In cases where the corneal infiltrate compromises the visual axis, topical corticosteroid therapy may be added to the regimen following at least 2 to 3 days of progressive improvement with topical antibiotic treatment, typically after identification of the pathogen. Topical antibiotics, which are generally administered more frequently than corticosteroids during treatment of active infection, are continued at high levels and tapered gradually. Patient compliance is essential, and the intraocular pressure must be monitored. The patient should be examined within 1 to 2 days after initiation of topical corticosteroid therapy.

Therapy for Complicated Cases
Coexisting risk factors, such as eyelid abnormalities, should be corrected for optimal results. Additional treatment is necessary in cases where the integrity of the eye is compromised, such as when there is an extremely thin cornea, impending or frank perforation, or progressive or unresponsive disease or endophthalmitis. Application of tissue adhesive, penetrating keratoplasty, and lamellar keratoplasty are among the treatment options. When corneal tissue is removed, it should be sent for pathologic and microbiologic analysis.

PROVIDER AND SETTING
The diagnosis and management of patients with bacterial keratitis require the clinical training and experience of an ophthalmologist, because the disease has the potential to cause visual loss or blindness. If the diagnosis or treatment is in question, or if the condition is severe or refractory to treatment, consultation with or referral to an ophthalmologist who has expertise and experience in the management of bacterial keratitis is desirable. The majority of patients with bacterial keratitis are treated on an outpatient basis. Hospitalization may be necessary if the keratitis is severe or vision-threatening, if compliance is impractical, or if pain is severe. Compliance may be doubtful due to the requirement for frequent instillation of eye drops, the patient's inability to instill the eye drops because of age, mental or physical disability, or the lack of an adequate support system at home.

COUNSELING/REFERRAL
Patients and care providers should be educated about the destructive nature of bacterial keratitis and the need for strict adherence to the therapeutic regimen. The possibility of permanent visual loss and need for future visual rehabilitation should be discussed. Patients who wear contact lenses should be educated about the increased risk of infection associated with contact lens wear, overnight wear, and the importance of adherence to techniques that promote contact lens hygiene. Visual rehabilitation restores functional ability, and patients with substantial visual impairment should be referred for vision rehabilitation and social services if they are not candidates for surgery. More information on vision rehabilitation, including materials for patients, is available at www.aao.org/smartsight.
Quality ophthalmic care is provided in a manner and with the skill that is consistent with the best interests of the patient. The discussion that follows characterizes the core elements of such care.

The ophthalmologist is first and foremost a physician. As such, the ophthalmologist demonstrates compassion and concern for the individual, and utilizes the science and art of medicine to help alleviate patient fear and suffering. The ophthalmologist strives to develop and maintain clinical skills at the highest feasible level, consistent with the needs of patients, through training and continuing education. The ophthalmologist evaluates those skills and medical knowledge in relation to the needs of the patient and responds accordingly. The ophthalmologist also ensures that needy patients receive necessary care directly or through referral to appropriate persons and facilities that will provide such care, and he or she supports activities that promote health and prevent disease and disability.

The ophthalmologist recognizes that disease places patients in a disadvantaged, dependent state. The ophthalmologist respects the dignity and integrity of his or her patients, and does not exploit their vulnerability.

Quality ophthalmic care has the following optimal attributes, among others.

- The essence of quality care is a meaningful partnership relationship between patient and physician. The ophthalmologist strives to communicate effectively with his or her patients, listening carefully to their needs and concerns. In turn, the ophthalmologist educates his or her patients about the nature and prognosis of their condition and about proper and appropriate therapeutic modalities. This is to ensure their meaningful participation (appropriate to their unique physical, intellectual and emotional state) in decisions affecting their management and care, to improve their motivation and compliance with the agreed plan of treatment, and to help alleviate their fears and concerns.

- The ophthalmologist uses his or her best judgment in choosing and timing appropriate diagnostic and therapeutic modalities as well as the frequency of evaluation and follow-up, with due regard to the urgency and nature of the patient's condition and unique needs and desires.

- The ophthalmologist carries out only those procedures for which he or she is adequately trained, experienced and competent, or, when necessary, is assisted by someone who is, depending on the urgency of the problem and availability and accessibility of alternative providers.

- Patients are assured access to, and continuity of, needed and appropriate ophthalmic care, which can be described as follows.
  - The ophthalmologist treats patients with due regard to timeliness, appropriateness, and his or her own ability to provide such care.
  - The operating ophthalmologist makes adequate provision for appropriate pre- and postoperative patient care.
  - When the ophthalmologist is unavailable for his or her patient, he or she provides appropriate alternate ophthalmic care, with adequate mechanisms for informing patients of the existence of such care and procedures for obtaining it.
  - The ophthalmologist refers patients to other ophthalmologists and eye care providers based on the timeliness and appropriateness of such referral, the patient's needs, the competence and qualifications of the person to whom the referral is made, and access and availability.
  - The ophthalmologist seeks appropriate consultation with due regard to the nature of the ocular or other medical or surgical problem. Consultants are suggested for their skill, competence, and accessibility. They receive as complete and accurate an accounting of the problem as necessary to provide efficient and effective advice or intervention, and in turn respond in an adequate and timely manner.
  - The ophthalmologist maintains complete and accurate medical records.
• On appropriate request, the ophthalmologist provides a full and accurate rendering of the patient's records in his or her possession.
• The ophthalmologist reviews the results of consultations and laboratory tests in a timely and effective manner and takes appropriate actions.
• The ophthalmologist and those who assist in providing care identify themselves and their profession.
• For patients whose conditions fail to respond to treatment and for whom further treatment is unavailable, the ophthalmologist provides proper professional support, counseling, rehabilitative and social services, and referral as appropriate and accessible.
• Prior to therapeutically or invasive diagnostic procedures, the ophthalmologist becomes appropriately conversant with the patient's condition by collecting pertinent historical information and performing relevant preoperative examinations. Additionally, he or she enables the patient to reach a fully informed decision by providing an accurate and truthful explanation of the diagnosis; the nature, purpose, risks, benefits, and probability of success of the proposed treatment and of alternative treatment; and the risks and benefits of no treatment.
• The ophthalmologist adopts new technology (e.g., drugs, devices, surgical techniques) in a judicious fashion, appropriate to the cost and potential benefit relative to existing alternatives and to its demonstrated safety and efficacy.
• The ophthalmologist enhances the quality of care he or she provides by periodically reviewing and assessing his or her personal performance in relation to established standards, and by revising or altering his or her practices and techniques appropriately.
• The ophthalmologist improves ophthalmic care by communicating to colleagues, through appropriate professional channels, knowledge gained through clinical research and practice. This includes alerting colleagues of instances of unusual or unexpected rates of complications and problems related to new drugs, devices or procedures.
• The ophthalmologist provides care in suitably staffed and equipped facilities adequate to deal with potential ocular and systemic complications requiring immediate attention.
• The ophthalmologist also provides ophthalmic care in a manner that is cost effective without unacceptably compromising accepted standards of quality.

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APPENDIX 2. SUMMARY OF MAJOR RECOMMENDATIONS FOR CARE

DIAGNOSIS

Evaluation of the patient with presumed bacterial keratitis includes those features of the comprehensive medical eye evaluation specifically relevant to bacterial keratitis, as listed below.

History

Obtaining a detailed history is important in evaluating patients with bacterial keratitis. Pertinent information includes the following:

- Ocular symptoms: e.g., degree of pain, redness, discharge, blurred vision, photophobia, duration of symptoms, circumstances surrounding the onset of symptoms
- Contact lens history: e.g., wearing schedule, overnight wear, type of contact lens, contact lens solution, contact lens hygiene protocol, tap-water rinse of contact lenses, swimming, using a hot tub, or showering while wearing contact lenses
- Review of other ocular history, including risk factors such as herpes simplex virus keratitis, varicella zoster virus keratitis, previous bacterial keratitis, trauma, dry eye, and previous ocular surgery, including refractive surgery
- Review of other medical problems and systemic medications
- Current and recently used ocular medications
- Medication allergies

Examination

The physical examination includes measurement of visual acuity, an external examination, and slit-lamp biomicroscopy.

Visual Acuity

In many cases, patient discomfort, tearing, and inflammation will compromise visual acuity. It is useful, however, to document baseline visual acuity and to ascertain that it is consistent with the anterior segment examination.

External Examination

An external examination should be performed with particular attention to the following:

- General appearance of the patient, including skin conditions
- Facial examination
- Globe position
- Eyelids and eyelid closure
- Conjunctiva
- Nasolacrimal apparatus
- Corneal sensation

Slit-Lamp Biomicroscopy

Clinical features suggestive of bacterial keratitis include suppurative stromal infiltrate (particularly those greater than 1 mm in size) with indistinct edges, edema, and white cell infiltration in surrounding stroma. An epithelial defect is typically present. An anterior chamber reaction is often seen.

Slit-lamp biomicroscopy should include evaluation of the following:

- Eyelid margins
- Conjunctiva
- Sclera
- Cornea
- Anterior chamber\(^{[A:III]}\) for depth and the presence of inflammation, including cell and flare, hypopyon, fibrin, hyphema
- Anterior vitreous\(^{[A:III]}\) for the presence of inflammation
- Contralateral eye for clues to etiology as well as possible similar pathology\(^{[A:III]}\)

**Diagnostic Tests**

**Cultures and Smears**

Smears and cultures are indicated in cases that involve a corneal infiltrate that is large and extends to the middle to deep stroma; that are chronic in nature or unresponsive to broad spectrum antibiotic therapy; or that have atypical clinical features suggestive of fungal, amoebic, or mycobacterial keratitis.\(^{45,46}\) The hypopyon that occurs in eyes with bacterial keratitis is usually sterile, and aqueous or vitreous taps should not be performed unless there is a high suspicion of microbial endophthalmitis, such as following an intraocular surgery, perforating trauma, or sepsis.\(^{[A:III]}\) Before initiating antimicrobial therapy, cultures are indicated in sight-threatening or severe keratitis of suspected microbial origin.\(^{[A:III]}\)

Corneal scrapings for culture should be inoculated directly onto appropriate culture media to maximize culture yield.\(^{52}\) If this is not feasible, specimens should be placed in transport media.\(^{53,54}\) In either case, cultures should be immediately incubated or taken promptly to the laboratory.\(^{[A:III]}\)

**TREATMENT AND FOLLOW-UP**

Topical antibiotic eye drops are capable of achieving high tissue levels and are the preferred method of treatment in most cases.\(^{46}\) See Table 2 in the main body of the text for recommendations about antibiotic therapy. For central or severe keratitis (e.g., deep stromal involvement or an infiltrate larger than 2 mm with extensive suppuration), a loading dose (e.g., every 5 to 15 minutes for the first 30 to 60 minutes), followed by frequent applications (e.g., every 30 minutes to 1 hour around the clock), is recommended.\(^{[A:III]}\)

Systemic therapy is necessary in cases of gonococcal keratitis.\(^{106}\)

Frequency of re-evaluation of the patient with bacterial keratitis depends on the extent of disease, but severe cases (e.g., deep stromal involvement or larger than 2 mm with extensive suppuration) initially should be followed at least daily until stabilization or clinical improvement is documented.\(^{[A:III]}\)

In general, the initial therapeutic regimen should be modified when the eye shows a lack of improvement or stabilization within 48 hours.\(^{[A:III]}\)

If there is a persistent epithelial defect and the infection is under control, adjunctive therapies to rehabilitate the surface should be instituted,\(^{[A:III]}\) such as lubrication, antibiotic ointment, or tarsorrhaphy.

Coexisting risk factors, such as eyelid abnormalities, should be corrected for optimal results.\(^{[A:III]}\)

**COUNSELING/REFERRAL**

Patients and care providers should be educated about the destructive nature of bacterial keratitis and the need for strict adherence to the therapeutic regimen.\(^{[A:III]}\) The possibility of permanent visual loss and need for future visual rehabilitation should be discussed.\(^{[A:III]}\) Patients who wear contact lenses should be educated about the increased risk of infection associated with contact lens wear, overnight wear, and the importance of adherence to techniques that promote contact lens hygiene.\(^{19,114-116}\)

Visual rehabilitation restores functional ability,\(^{117}\) and patients with substantial visual impairment should be referred for vision rehabilitation and social services if they are not candidates for surgery.\(^{118}\) More information on vision rehabilitation, including materials for patients, is available at [www.aao.org/smartsight](http://www.aao.org/smartsight).
APPENDIX 3. CONTACT LENS CARE

The following recommendations have been excerpted from the Refractive Errors & Refractive Surgery Preferred Practice Pattern.119

PATIENT EDUCATION AND CONTACT LENS CARE

The United States Food and Drug Administration (FDA) has made the following recommendations for contact lens wearers regarding proper lens care practices:36[A:III]

◆ Wash hands with soap and water, and dry (lint-free method) before handling contact lenses.
◆ Wear and replace contact lenses according to the schedule prescribed by the doctor.
◆ Follow the specific contact lens cleaning and storage guidelines from the doctor and the solution manufacturer.
◆ Keep the contact lens case clean and replace every 3 to 6 months.
◆ Remove the contact lenses and consult your doctor immediately if you experience symptoms such as redness, pain, tearing, increased light sensitivity, blurry vision, or swelling.

When contact lenses are initially dispensed, patients should understand and practice contact lens insertion and removal.[A:III] Contact lens cleaning and disinfection should be carefully explained, since improper care may be associated with complications of contact lens wear.120,121[A:II] Patients should be instructed to use only sterile products that are commercially prepared specifically for contact lens care and to replace these at the intervals recommended by the manufacturers.122[A:III] Specifically, patients should be instructed not to rinse contact lenses or lens cases with nonsterile water, e.g., tap water, bottled water. Patients should also be instructed to clean and replace contact lens cases frequently[B:III] because they can be a source of lens contamination.121,122 Patients should be instructed to replace the solution in contact lens cases each time the lenses are disinfected (i.e., old solution should not be “topped off”).124[A:III]

Patients should be made aware that using contact lenses can be associated with the development of ocular problems, including microbial corneal ulcers that may be vision threatening, and that overnight wear of contact lenses is associated with an increased risk of ulcerative keratitis.19,115,116[A:II] The increased risk of ulcerative keratitis with extended contact lens wear should be discussed with patients who are considering this modality of vision correction.19[A:II] If patients choose overnight wear, they should be instructed to use only lenses specifically approved for extended wear.

Swimming with contact lenses has been associated with the development of Acanthamoeba keratitis.118 Therefore, patients should be instructed to minimize water contact when wearing contact lenses and informed of the risks of wearing contact lenses while swimming or in a hot tub. Directions for use of a no-rub solution require that a steady stream of the product be directed at the contact lens for a specific length of time. In general, however, rubbing the contact lenses during cleaning and rinsing with contact lens solution is considered by some experts to be a superior method of cleaning.125,126

CONTACT LENS CARE

Proper contact lens care involves a combination of cleaning, disinfecting, rinsing, and wetting solutions. Surfactant cleaning solutions act like detergents to solubilize debris that is not chemically bonded to the contact lens. Rubbing the contact lens is believed to enhance the cleaning performance of the solution. Enzymatic cleaners remove deposits that are chemically bonded to the surface. Disinfecting solutions reduce the number of microorganisms carried on the contact lens. Wetting solutions make a water-repellant lens surface hydrophilic. Many manufacturers combine these agents into multipurpose solutions. Certain multipurpose contact lens care solutions have been linked to outbreaks of Fusarium and Acanthamoeba keratitis.64,73,125 Patients should also be instructed to clean and replace contact lens cases frequently.[B:III] because they can be a source of lens contamination,121,123 and damaged or cracked cases should be discarded.

The American Academy of Ophthalmology (www.ao.org/store) and the Contact Lens Association of Ophthalmologists (www.clao.org/Publications/Products/tabid/87/Default.aspx) have patient information brochures for contact lens care.
Table A4-1 lists diagnostic stains that are used in cultures to identify causes of bacterial keratitis.

### TABLE A4-1  STAINS USED TO IDENTIFY COMMON CAUSES OF BACTERIAL KERATITIS IN THE UNITED STATES

<table>
<thead>
<tr>
<th>Type of Stain</th>
<th>Organisms Visualized</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gram stain*</td>
<td>Best for bacteria; can also visualize fungi,† amoeba</td>
<td>Distinguishes gram-positive from gram-negative organisms; widely available; rapid (5 minutes)</td>
</tr>
<tr>
<td>Giemsa stain*</td>
<td>Bacteria, fungi,† Chlamydia, Acanthamoeba</td>
<td>Basis for Aema-color and Diff-Quik tests; widely available; rapid (2 minutes)</td>
</tr>
<tr>
<td>Acid fast</td>
<td>Mycobacterium, Nocardia</td>
<td>Widely available; takes 1 hour; reliable stain for Mycobacteria</td>
</tr>
<tr>
<td>Acridine orange*</td>
<td>Bacteria, fungi,† Acanthamoeba²</td>
<td>Requires use of epifluorescent microscope; rapid (2 minutes)</td>
</tr>
<tr>
<td>Calcofluor white</td>
<td>Fungi,† Acanthamoeba²</td>
<td>Requires use of epifluorescent microscope; rapid (2 minutes)</td>
</tr>
</tbody>
</table>

* Most useful stains for screening purposes.
† PAS (periodic acid-Schiff) and GMS (Gomori methenamine silver) also can be used to identify fungi.
‡ H&E (hematoxylin and eosin) and PAS also can be used to identify Acanthamoeba.

Data from:
# APPENDIX 5. CULTURE MEDIA

Table A5-1 lists culture media that are used in the management of bacterial keratitis.

## TABLE A5-1  CULTURE MEDIA FOR BACTERIALKERATITIS

<table>
<thead>
<tr>
<th>Media</th>
<th>Common Isolates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard</strong></td>
<td></td>
</tr>
<tr>
<td>Blood agar</td>
<td>Aerobic and facultatively anaerobic bacteria, including P. aeruginosa, S. aureus,</td>
</tr>
<tr>
<td></td>
<td>S. epidermidis, and S. pneumoniae</td>
</tr>
<tr>
<td>Chocolate agar</td>
<td>Aerobic and facultatively anaerobic bacteria, including H. influenzae, N. gonorrhoea, and Bartonella species</td>
</tr>
<tr>
<td>Thioglycollate broth</td>
<td>Aerobic and facultatively anaerobic bacteria</td>
</tr>
<tr>
<td>Sabouraud dextrose agar</td>
<td>Fungi</td>
</tr>
<tr>
<td><strong>Supplemental</strong></td>
<td></td>
</tr>
<tr>
<td>Anaerobic blood agar (CDC,</td>
<td>P. acnes, Peptostreptococcus</td>
</tr>
<tr>
<td>Schaedler, Brucella)</td>
<td></td>
</tr>
<tr>
<td>Löwenstein-Jensen medium</td>
<td>Mycobacterium species, Nocardia species</td>
</tr>
<tr>
<td>Middlebrook agar</td>
<td>Mycobacterium species</td>
</tr>
<tr>
<td>Thayer-Martin agar</td>
<td>Pathogenic Neisseria species</td>
</tr>
</tbody>
</table>

**NOTE:** Fungi and Acanthamoeba can be recovered on blood agar. However, more specific media are available (fungi: Sabouraud dextrose agar, brain-heart infusion agar; *Acanthamoeba*: buffered charcoal yeast extract, non-nutrient agar with *E. coli* overlay).

References:
APPENDIX 6. PREPARATION OF FORTIFIED TOPICAL ANTIBIOTICS

Instructions for preparing fortified topical antibiotics used in treating bacterial keratitis are as follows:

Cefazolin 50 mg/ml or Ceftazidime 50 mg/ml
1. Add 9.2 ml of artificial tears to a vial of cefazolin, 1 g (powder for injection).
2. Dissolve. Take 5 ml of this solution and add it to 5 ml of artificial tears.
3. Refrigerate and shake well before instillation.

Tobramycin 14 mg/ml or Gentamicin 14 mg/ml
1. Withdraw 2 ml from an injectable vial of intravenous tobramycin or gentamicin (40 mg/ml).
2. Add the withdrawn 2 ml to a 5 ml bottle of tobramycin or gentamicin ophthalmic solution to give a 14 mg/ml solution.
3. Refrigerate and shake well before instillation.

Vancomycin 15 mg/ml, Vancomycin 25 mg/ml, or Vancomycin 50 mg/ml
1. To a 500 mg vial of vancomycin:
   a. Add 33 ml of 0.9% sodium chloride for injection USP (no preservatives) or artificial tears to produce a solution of 15 mg/ml.
   b. Add 20 ml of 0.9% sodium chloride for injection USP (no preservatives) or artificial tears to produce a solution of 25 mg/ml.
   c. Add 10 ml of 0.9% sodium chloride for injection USP (no preservatives) or artificial tears to produce a solution of 50 mg/ml.
2. Refrigerate and shake well before instillation.

Amikacin
Intravenous formulation can be used (80 mg/2 cc ampules).

Trimethoprim/sulfamethoxazole
16 mg/ml and 80 mg/ml commercial preparation can be used.

RELATED ACADEMY MATERIALS

Basic and Clinical Science Course
External Disease and Cornea (Section 8, 2011-2012)

Eye Fact Sheets
Herpes Simplex Eye Disease (2008)

Information Statement
Extended Wear of Contact Lenses (2008)

Patient Education Brochure
Contact Lenses (2011)

Preferred Practice Patterns
Comprehensive Adult Medical Eye Evaluation (2010)
Pediatric Eye Evaluations (2007)

To order any of these materials, please call the Academy’s Customer Service number, 866.561.8558 (U.S. only) or 415.561.8540 or visit www.aao.org/store.

REFERENCES

45. Wilhelmus K, Liesegang TJ, Osato MS, Jones DB. Laboratory diagnosis of ocular infections. Washington DC: American Society for Microbiology, 1994; Cumitech Series #13A.


