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Efficacy of Detergent and Water Versus Bleach for the Disinfection of Direct Contact Ophthalmic Lenses

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Abstract

Purpose—While manufacturers recommend cleaning ophthalmic lenses with detergent and water and then a specific disinfectant, disinfectants are rarely used in ophthalmic practices. The aim of this pilot study was to evaluate the efficacy of detergent and water versus bleach, a recommended disinfectant, to eliminate common ocular bacteria and viruses from ophthalmic lenses.

Methods—Three bacterial strains (*Staphylococcus epidermidis*, *Corynebacterium straitum*, and methicillin-resistant *Staphylococcus aureus* (MRSA) and two viral strains (adenovirus and herpes simplex virus (HSV) type-1) were individually inoculated to 20 gonioscopy and laser lenses. Lenses were washed with detergent and water and then disinfected with 10% bleach. All lenses were cultured after inoculation, after detergent and water, and after the bleach. Bacterial cultures in thioglycollate broth were observed for 3 weeks and viral cultures for 2 weeks. The presence of viruses was also detected by multiplex polymerase chain reaction (PCR).

Results—All 20 lenses inoculated with *Staphylococcus epidermidis*, *Corynebacterium straitum*, *adenovirus*, and *HSV-1* showed growth after inoculation, but no growth after detergent/water and after the bleach. All lenses showed positive HSV and adenovirus PCR after inoculation and negative PCR after detergent/water and after bleach. All MRSA contaminated lenses showed growth after inoculation and no growth after detergent and water. However, one lens showed positive growth after bleach.

Conclusions—Cleaning with detergent and water appeared to effectively eliminate bacteria and viruses from the surface of contaminated ophthalmic lenses. Further studies are warranted to design practical disinfection protocols that minimize lens damage.

Keywords

bleach; detergent; disinfection; ophthalmic lenses; soap

Introduction

Veterans Affairs (VA) Hospitals mandate that all reusable medical equipment is disinfected strictly according to manufacturers' guidelines. According to Earle H. Spaulding's classification scheme, reusable ophthalmic devices which come in contact with intact mucous membranes, such as gonioscopy and direct contact laser lenses, applanation tonometry prisms, and ophthalmic ultrasound probes, are considered semicritical items.¹ According to the Centers for Disease Control and Prevention (CDC), semicritical items should be free from all microorganisms, however small numbers of bacterial spores are permissible.²

Ocular Instruments Inc. (Bellevue, WA, www.ocularinc.com) and Volk Optical Inc. (Mentor, OH, <http://volk.com>), major ophthalmic lens manufacturers, caution against cleaning lenses with such Food and Drug Administration (FDA) approved high-level disinfectants as alcohol or peroxide since these chemicals cause lens surface damage. Both Ocular and Volk recommend cleaning lenses with detergent and water and then with a disinfectant. Volk Optical Inc. gives several disinfectant options, including 1:10 sodium hypochlorite (bleach) solution, cidex OPA, glutaraldehyde, bode mikorbac tissues, and CaviWipes.³

Bleach is a widely available and low-cost disinfectant that is commonly used for ophthalmic equipment within the VA Healthcare system (internal communication). Numerous cycles of bleaching result in anti-reflective coating deterioration and lens damage thereby increasing equipment cost to the hospital. Since the VA mandates that lenses can only be processed by trained personnel- usually by the Sterile Processing and Distribution department- according to highly scrutinized and approved protocols, patient care delays frequently occur and multiple copies of the same lens are required to compensate for lens turn-over. On the other hand, community ophthalmic practices rarely use disinfectants, and there are no publications reporting infectious epidemics caused by ophthalmic lenses. A common practice in our community is to wash lenses with water and soap without further disinfection (internal communication).

No scientific studies evaluating disinfection methods used in ophthalmic practices or those recommended by the manufacturers are available. Within the VA system the wear and tear on the lenses due to multiple rounds of bleaching is significant as are the extra costs and personnel required for lens processing. The aim of this pilot laboratory study was to evaluate efficacy of detergent and water versus bleach to reduce microbial bioburden on ophthalmic lenses.

Materials and Methods

The study is a prospective pilot laboratory investigation utilizing common conjunctival bacteria and viruses inoculated individually to 20 gonioscopy and direct contact laser lenses. The following common ocular microorganisms had been isolated from patients as part of routine clinical care and are utilized for research purposes at the Bascom Palmer Eye Institute Microbiology Laboratory: *Staphylococcus epidermidis* (*S. epidermidis*),

Corynebacterium straitum (*C. straitum*), methicillin-resistant *Staphylococcus aureus* (MRSA), adenovirus, and Herpes Simplex Virus, Type 1 (HSV-1). To obtain sufficient amounts of organisms for this study, these bacterial isolates were re-grown on 5% sheep blood agar plates. Viral isolates were re-grown in A549 cell tissue culture (Diagnostic Hybrids, Athens, OH). Bacteria were then re-suspended in trypticase soy broth, while the viruses were re-suspended in A549 tissue culture medium. Each solution was adjusted to a final concentration of 10^6 colony forming units (CFU)/ml using a spectrophotometer (Fisher Scientific, Pittsburgh, PA).

The following twenty direct contact ophthalmic lenses were utilized:

- Two Ocular Instruments® Sussman Four Mirror Gonioscopy Lenses
- Two Ocular Instruments® OMRA Mainster Retina Laser Lenses
- Two Ocular Instruments® OG3MA Three Mirror Universal Laser Lenses
- Two Volk® Super Quad 160 Fundus Laser Lenses
- Two Volk® G-2 Trabeculum Lenses
- Two Volk® G-3 Goniofundus Lenses
- Four Volk® G-4 Gonioscopy Lenses
- Two Volk® Quadraspheric Fundus Lenses
- Two Volk® Three-Mirror Gonioscopy/Fundus Lenses

Inoculating lenses and confirming bacterial and viral viability

Working with each microorganism separately, five experiments were conducted as described below (Figure 1). Lenses were soaked in 10% bleach for 25 minutes, thoroughly rinsed with tap water, and dried with a fresh lint-free tissue (Kimwipe, Kimberly-Clark, Irving TX) between the experiments.

In each experiment, 0.1-mL of microorganism solution (10^6 CFU/ml) was inoculated onto concavity of each lens with a pipette. Ten minutes later a sterile cotton tip was used to culture each lens as a positive control to confirm viability of the microorganism.

Lens culturing

The cotton tip used to swab each lens was delivered to a fresh tube of thioglycollate broth for bacteria or 1 ml of viral transport medium, 0.4 ml of which was then added to the A549 tissue culture for viruses. Each bacterial culture was observed for 3 weeks and each viral culture for 2 weeks. The presence of bacteria was detected by monitoring for broth turbidity, and the presence of each virus was confirmed by detection of typical cytopathic effect under the microscope daily. At the end of 14 days multiplex polymerase chain reaction (PCR) was performed using HSV-1 and adenovirus primers as described below.

Next each lens was cleaned and disinfected according to manufacturer's instructions (per package inserts) and re-cultured twice as described below and diagramed in Figure 1.

Step 1: Detergent and water Cleaning—Each lens was rinsed for 10 seconds with tap water. The lens was then cleaned with Liquiclean detergent (Ruhof Corp., Mineola, NY) solution (diluted 1 part detergent to 4 parts tap water) and a sterile cotton swab for 30 seconds. Next the lens was rinsed with tap water for 10 seconds and dried with a Kimwipe. Then the concavity of each lens was swabbed with a sterile cotton swab moistened in the respective culture medium to a fresh tube of thioglycollate broth for bacteria or viral transport medium/A549 tissue culture for viruses.

Step 2. Bleach—Each lens was then soaked in 10% Sodium Hypochlorite solution (1 part bleach and nine parts water). Ocular lenses were soaked for 10 minutes (per Ocular 2005 package insert, 8428J3151) (Ocular Instruments, Inc., Bellevue, WA) and Volk lenses were soaked for 25 minutes (per Volk 2007 package insert, IM-008, 03.01.07) (Volk Optical, Mentor, OH).

Step 3. Rinse—The lens was then rinsed with tap water for 3 cycles of 1 minute each and dried with a Kimwipe. Each lens concavity was then swabbed with a sterile cotton swab moistened in respective culture medium to a fresh tube of thioglycollate broth for bacteria or viral transport medium/A549 tissue culture for viruses as described under Lens Culturing above.

Multiplex PCR

A549 cell cultures inoculated with HSV-1 or adenovirus were held for 2 weeks. At day 14, 0.1-ml of both viral supernatants were screened by multiplex PCR technique previously described, using adenovirus and HSV primers.⁴ The PCR reaction (asymmetric) was performed using HotStarTaq Master Mix Kit (Invitrogen, Carlsbad, CA) utilizing 12 µL of Ultra-Pure DEPC-treated water (Invitrogen), 25 µL of HotStarTaq Master Mix, and 2 µL of each primer. The cycling parameters were: 1 cycle at 94°C for 7 minutes, followed by 30 cycles of 2 minutes at 94 °C, 1.5 minutes at 45 °C, and 2 minutes at 70 °C. The amplified products were detected by electrophoresis in a 1.5% agarose gel.

Results

When inoculated with *Staphylococcus epidermidis* or *Corynebacterium straitum*, all 20 lenses yielded heavy broth turbidity confirming the presence of bacteria on the lens (positive control). After washing with detergent and water, none of the 20 lenses demonstrated growth. None of the lenses showed growth after the bleach disinfection. MRSA produced 20 positive control cultures after inoculation, and none of the lenses had growth after detergent and water. However, 1 of 20 lenses (a Volk lens) showed positive growth after bleach disinfection.

For adenovirus and HSV-1, positive control samples from each lens uniformly demonstrated cytopathic effect and the presence of the virus by multiplex PCR. None of the 20 lenses showed cytopathic effect or the presence of adenoviral or HSV DNA after detergent and water and after bleach soaking.

Discussion

In this pilot study detergent and water eliminated common bacteria and viruses from the surface of gonioscopy and laser lenses contaminated in the laboratory. Disinfection with bleach did not add any additional benefit. In fact, one of the MRSA-contaminated lenses showed no growth after detergent/water but positive growth after the bleach possibly due to secondary contamination during lens handling. In a clinical setting, it is possible that handling bleached lenses with non-sterile hands may result in introduction of microorganisms onto the lens and the patient's eye. Since these lenses are usually used on non-infected patients in a non-sterile clinical setting, where the provider handles the lens while touching the patient's lids and lashes with ungloved hands, it seems that good hand-washing technique and thoroughly washing the lenses with detergent and water would be effective means of assuring patient safety. Future studies comparing the number of microorganisms present on lenses in different clinical scenarios would be helpful.

To our knowledge, no previously published study evaluated efficacy of cleaning methods used for ophthalmic lenses. In the last several years, Veterans Affairs eye care services have come under intense scrutiny to assure that all items coming in contact with the eye are processed according to manufacturers' recommendations. However, manufacturers' recommendations were neither designed nor tested in a clinical setting. The results of this pilot study suggest that simple washing with detergent and water, which can be easily performed in the exam room during hand-washing, may effectively eliminate common ocular microorganisms from ophthalmic lenses. Frequent disinfection with bleach leads to lens damage, and thus, increasing cost to ophthalmic practices. Future studies are warranted to outline practical guidelines which assure adequate disinfection while minimizing damage to the lenses.

We utilized common bacteria of conjunctival flora, coagulase-negative Staphylococci and Corynebacteria,^{5,6} as well as common ocular pathogens, MRSA, adenovirus, and HSV-1. We inoculated 10^5 organisms on each lens. In the clinical setting prior to applying the lens to the patient's eye, lens concavity is filled with either saline or goniosol, hence host's flora may be diluted and adherence of the microorganisms to the lens surface may be reduced compared to the inoculation of highly concentrated solutions employed in our study. In this study, microbial solutions were left on the lenses for 10 minutes- longer than the usual gonioscopy or laser procedure- to allow microorganism to adhere to the lens surface. The aim of this pilot study was to compare the qualitative efficacy of detergent and water versus bleach, looking for complete elimination of microorganisms from the lenses, therefore the organisms growing in thioglycollate broth or viral medium were neither identified nor quantified.

A limitation of this pilot study is the relatively small lens sample size (n=20) and laboratory setting. It would be meaningful to replicate our findings in a large clinical study with lenses used for patient care. On the other hand, conducting this study in a laboratory made it possible to uniformly inoculate lenses with a controlled amount of microorganisms and to eliminate the variability in the types and amount of normal corneoscleral flora found in different patients.^{5,6} However, it is possible that the techniques used in this pilot study may

not adequately represent the transmission modalities for pathogens implicated in ocular infections. The use of disposable instruments represents a lower-risk alternative. Unfortunately, no disposable lenses are available.

Disinfection of reusable ophthalmic equipment is essential for prevention of healthcare-associated epidemics. Several reports of nosocomially spread epidemic keratoconjunctivitis have been published.⁷⁻⁹ Any equipment used on an infected patient must be strictly disinfected. However, it is difficult to decide on a disinfection protocol that would be universally effective. For example, to prevent spread of adenovirus, the CDC have recommended that tonometer prisms be disinfected for 5–10 minutes with either 3% hydrogen peroxide, 5000 ppm chlorine, 70% ethyl alcohol, or 70% isopropyl alcohol.² However, recent data suggest that 3% hydrogen peroxide and 70% isopropyl alcohol are not effective against adenovirus type 8.⁹ Rutala et al. demonstrated that only 0.55% ortho-phthalaldehyde, 2.4% glutaraldehyde, 2.65% glutaraldehyde, 6,000 ppm chlorine, and 1,900 ppm chlorine were effective after a 1-minute exposure.⁹ Segal et al. studied disinfection of Goldmann tonometer prisms after contamination with hepatitis C virus.¹⁰ The authors reported percentage of hepatitis C virus RNA remaining after cleaning with dry gauze (95.65%), 70% isopropyl alcohol 5-second wipes (88.91%), cold water 10-second wash (4.78%), 10% povidone-iodine 5-second wipes (0.72%), 3% hydrogen peroxide 5-minute soak with subsequent 5-second cold water wash (0.07%), and 70% isopropyl alcohol 5-minute soak followed by 5-minute cold water wash (0.02%). Pepose et al. demonstrated that wiping Goldmann tonometer tips with sterile gauze soaked with 3% hydrogen peroxide or with a 70% isopropyl alcohol swab and then allowing the alcohol to evaporate provides efficient means of inactivating HIV, HSV type 1 and HSV type 2 viruses.¹¹ According to the Volk Ophthalmic Inc., the ophthalmic lenses should never be cleaned with alcohol, peroxide or acetone to avoid lens surface damage,³ therefore these disinfectants are not utilized on ophthalmic lenses within the VA Hospitals.

Although our results suggest that simple washing with detergent and water might be effective in eliminating common ocular surface flora and certain pathogens from ophthalmic lenses, lenses used on infected patients should be disinfected more stringently according to the guidelines recommended by the CDC. Future disinfection studies are warranted to design effective disinfection protocols which are practical and cost effective.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Algorithm for lens inoculation, cleaning, disinfection and culturing.