Disinfection of Multi-Patient Contact Lenses in the Clinical Setting

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The safe wearing of contact lenses and care to help prevent against infection have many parameters, including corneal, limbal or scleral fit, wear time, storage case considerations, hygiene of hands, face and lids, solutions used for cleaning, storage and wear of a lens and the susceptibility of the patient to infection (e.g. immunocompromised through disease or medication). This policy paper will focus on minimizing infection of multi-patient lenses used in the clinical setting. Reusable contact lenses are defined by the International Organization for Standardization (ISO) standards as follows[1]:

> **Trial contact lens / diagnostic contact lens**
> Contact lens only used by a practitioner or fitter for the purpose of selecting the appropriate contact lens parameters for the intended wearer
>
> **Multi-patient use trial contact lens**
> Trial contact lens permitted to be used on more than one person

Scope of the Problem

Infection from a contact lens can occur by single or multiple microbial agents including bacterial, fungal, viral, parasitic or amoebic, or other transmissible origins. Each has different avenues and barriers to a lens, and its survivability can depend on the lens material (soft hydrogel lenses, gas permeable plastics, and variations in polymers from different manufacturers).

Transmission of infection can occur in the tears, lids, lashes, cornea, and deeper layers of the eye, depending on the nature of the infector and where patients are most susceptible and vulnerable to infection. Left untreated, infections can cause compromised tissue, discomfort, light sensitivity, visual changes, scarring, and even permanent loss of vision. Diagnosis and treatment of infections from contact lenses should be swift and specific for the offending agent, for the best visual and ocular outcomes. Because this paper will focus on reusable contact lenses in the clinical setting, the emphasis will be on preventing vision and eye health compromise, among patients requiring a trial contact lens fit, from infecting agents on various trial lens materials.

Offending Agents: Bacterial, Viral, Fungal, Parasitic/Amoebae and Other (Prion)

<u>Bacterial</u>

Pseudomonas aeruginosa is a gram-negative, rod-shaped bacterium that is becoming increasingly opportunistic, adapting and resisting some antibiotics. It is found on skin, soil, water, and most man-made environments around the world and is citrate (acid), catalase (enzymatic) and oxidase (electron transfer) positive. It can live in clusters or create large films of colonization.

P. aeruginosa can activate several pathways of the immune system during microbial keratitis, and activation often involves receptors on the corneal epithelial cells called toll-like receptors (TLRs). These TLRs recognize e.g., lipopolysaccharide or flagella from P. aeruginosa and activate the epithelial cells to produce inflammatory mediators such as cytokines and chemokines. These cytokines or chemokines recruit white blood cells, predominantly polymorphonuclear leukocytes, to the infection so that they can phagocytose and kill the P. aeruginosa. However, continued recruitment and presence of these polymorphonuclear neutrophils (PMNs) and other white blood cells in the corneal tissue leads to destruction of corneal cells and tissue components. This can ultimately lead to scarring and vision loss.[2] Factors that play important roles in the adhesion process of bacteria to contact lenses include: surface hydrophobicity/net surface charge and host receptor interaction, and binding molecules present on the bacterial cells. Bacterial adherence to the epithelial surface occurs due to molecular interactions between bacterial surface proteins and protein receptors on the cell surfaces. Surface hydrophobicity of the contact lens has been found to enhance bacterial adhesion.[3]

Prevention of *P. aeruginosa* is accomplished generally with cleaning solutions and treatment is accomplished via antibiotics specific to the patient's strain. The Centers for Disease Control and Prevention (CDC) also receives *P. aeruginosa* variants and has confirmed several plasmid-mediated carbapenemases, more resistant to existing antibiotics, in their search for newer drug combatants.

Staphylococcus aureus is a gram-positive, round-shaped bacteria that is common in - and on - the human body (most commonly in the nose). It is catalase and nitrate positive and a facultative anaerobe (can grow without oxygen). It promotes itself via the production of protein toxins that bind to antibodies. Resistant strains of *S. aureus* recently include: methicillin-resistant S. aureus (MRSA), Vancomycin-intermediate S. aureus (VISA) and Vancomycin-resistant S. aureus (VRSA), causing more serious infections in immunocompromised patients. S. aureus is carried by 50 to 60 percent of the normal population on the hands, face, nose, and skin.[4] One study showed that S. aureus is the most common bacterial cause of contact-lens-induced peripheral ulceration.[5]

Viral

Herpes Simplex Virus Type 1 (HSV-1) is the most common virus found in the eye and is also common on the lips and mouth. The virus is usually transmitted through oral secretions or sores or via shared objects (e.g., toothbrushes, utensils). Globally, more than 3.7 million people (67 percent of people age 0 to 49) have asymptomatic HSV-1 and it can be transmitted with or without symptoms[6]. HSV-1 usually resolves with and without treatment (antiviral medications such as acyclovir, famciclovir, and valacyclovir) and can cause severe corneal pain and sometimes corneal scarring.

Adenovirus is known to have over 50 species and most commonly cause upper and lower respiratory tract infections. They are thought to cause 65 to 90 percent of viral conjunctivitis infections.[7] Adenoviruses have an incubation period of 5 to 12 days, usually resolving on their own after a few

weeks, and are highly contagious. Several trials are underway for the treatment of adenovirus, but the treatment toxicities are usually more burdensome than letting the disease run its course. Epidemic keratoconjunctivitis (EKC) is the common form of adenovirus causing dry eye and possible conjunctival scarring.

Human T-lymphotropic virus type III/lymphadenopathy (HTLV-III/LAV) is the etiologic agent of acquired immunodeficiency syndrome (AIDS). The AIDS virus has been variously termed HTLV-III, lymphadenopathy-associated virus (LAV), AIDS-associated retrovirus (ARV), or human immunodeficiency virus (HIV). These patients may present with a range of asymptomatic infection to severe immunodeficiency and life-threatening infections, diseases, and cancers.

HTLV-III/LAV has been recovered from tears and ocular tissue of infected patients. Although the risk of transmission is low via tears and contact lenses, clinicians must be aware of the risk from opportunistic pathogens and the patient's own increased risk of corneal infection with contact lens wear. Approximately 70 percent of patients with advanced HTLV-III/LAV /HIV will be treated for an AIDS-associated eye disorder during the course of their illness.[8]

Hepatitis B/C Virus (HBV and HCV) – HBV is the most common cause of liver cancer and is transmitted via sexual contact, needle sharing, blood transfusion, and/or mother to child during birth. In the eye, infectious HBV can cause retinal vasculitis, third nerve palsy, and optic neuritis/uveitis. Treatments for HBV, such as interferons, can themselves cause eye problems. HCV has been found more commonly in tears, causing dry eye and corneal thinning, but less pathognomonic infections[9].

Fungal

Fusarium (Aspergillus and Candida species) are the most common fungal infections found in the eye. Aspergillus are conidial fungi (asexual, also called Ascomycota). They are commonly known as molds and grow in environments of high-carbon contents such as sugar concentrations. They can, however, also grow in nutrient-depleted environments, such as mildew. More than 60 species of Aspergillus have become medical pathogens. The most common types of pathogen Aspergillus appear in sinus infections, causing fever, cough, and breathing problems, especially in those with auto-compromised conditions. When they enter the eye via surgery, trauma, or other lesions, they can cause endophthalmitis, resulting in severe eye pain and vision loss. Aspergillus endophthalmitis requires aggressive treatment with amphotericin B, voriconazole, caspofugin, and/or corticosteroids.

Candida is normally present on the skin, intestines, and genital areas. Infections can occur in healthy individuals and those with auto-compromised conditions. Normally occurring bacteria digest Candida; so those taking antibiotics are at a higher risk for infection. Candida can spread via the blood to other organs, and in the eye can cause irritation, discharge, light sensitivity, and vision loss. Candida is treated with topical, oral, and injectable antifungal medications named above.

In the northern United States, Candida sp. has typically been the major etiologic agent for fungal keratitis, whereas in the southern United States, Fusarium sp. is the major causative agent.[10] Candida infections tend to occur in patients with compromised ocular surfaces, for example, associated with ocular trauma with soil or vegetative matter contamination.[11] Despite being a less common cause of microbial keratitis, fungal keratitis accounts for approximately 50 percent of all microbial keratitis cases that require therapeutic penetrating keratoplasty.[12]

Parasitic/Amoebae

……*Acanthamoeba* is a single celled eukaryote (nucleus is within its membrane) organism found on the human body and in air, soil, and fresh and treated water. It can be metabolically active (trophozoite stage) or dormant and stress-resistant (cyst stage). Acanthamoeba keratitis is rare, but contact lens wearers account for 90 percent of cases, and the number of cases being reported is occurring with increasing frequency.[13] They can cause severe corneal infections, as well as infections of the central nervous system, most severe in those with immunodeficiency. Infections can mimic bacterial leptomeningitis, tuberculosis meningitis, or viral encephalitis. When found in the eye, Acanthamoeba strains can cause corneal ulcers and even blindness. The current treatments for Acanthamoeba are amphotericin B, rifampicin, trimethoprim-sulfamethoxazole, ketoconazole, fluconazole, sulfadiazine, or albendazole. Making Acanthamoeba more complicated are some strains of bacteria (Legionella pneumophila, Pseudomonas aeruginosa, and some Escherichia coli and Staphylococcus aureus) that can infect and replicate with Acanthamoeba species, using the Acanthamoeba as their own reservoir.

Other/Prion

Prions are transmissible spongiform pathogenic agents that are able to induce abnormal folding of normal cell proteins, making them perform abnormally. These proteins are most abundant in the brain, and if their amino acid chain folds and become resistant to protease breakdown, they become rapidly progressive and fatal. Forms of Prion are also called Creutzfeldt-Jakob Disease (CJD), Variant Creutzfeldt-Jakob Disease (vCJD), Bovine Spongiform Encephalopathy (BSE) and Chronic Wasting Disease (CWD). Prion disease causes vacuolation of the brain that gives the tissue the sponge-like appearance, which gives rise to the term 'spongiform encephalopathy'.[14] Prions can be transmissible spongiform encephalopathies (TSEs) with four different types of the variant vCJD with an earlier onset psychiatric presentation and extensive brain plaque development. Common visual symptoms include diplopia, supranuclear palsies, homonymous visual field defects, hallucinations, and cortical blindness. These variations accumulate in lymphoid, spleen, and tonsil tissue. Human corneal dendritic cells have lymphoid tissue, raising possible, but highly improbable transmission concerns between patients and optical devices such as contact lenses. Corneal transplant patients, however, may have a higher risk of disease transmission via the transplant and optic nerve, warranting a careful risk assessment after surgery.

In the case of the human TSEs, only a small proportion of cases are due to transmission (via experiment) and the majority are termed sporadic because there is no evidence of transmission. The fact that these diseases can be sporadic, transmitted or inherited is a feature unique to the prion diseases. All other infectious diseases can have one of these as a possible etiology but never more than one.[14]

Because Prion have been found in corneal tissue, clinical instruments, contact lenses and other direct eye contact devices all have implications in disease management.

Contact Lens Variabilities and Disease Transmission

We've established that this paper will address disinfection of multi-use/multi-patient contact lenses used in the clinical setting. However, there are several other clinical assumptions that must be made for this paper's purpose when discussing disease transmission:

1. Office staff hygiene can be a factor in transmission of disease. We will assume for this paper that all clinicians follow the CDC guidelines on hand washing and hand gloving. The CDC infection control guidelines can be found here: https://www.cdc.gov/infectioncontrol/guidelines/disinfection/index.html
2. Office staff will adhere to expiration dates of all solutions used for disinfection and storage. Noncompliance will not be included as a contributor to the infectious agents mentioned here.
3. Office staff will maintain and disinfect office equipment according to CDC guidelines found in the link above.
4. Patient compliance to cleaning, storing, and wear time is not a factor in this report, as multi-patient lenses are not handled by patients and only used in the clinical setting for fitting and diagnostic purposes. We will mention in this report the different types of cleaning, disinfecting, and storage solutions available to patients; however, the clinician should follow a more rigorous disinfection protocol which we will also review.
5. Types of contact lenses will fall into three categories for disinfection purposes:
    a. Soft Contact Lenses – to include silicone-hydrogels, extended wear, and disposables
    b. Rigid Gas Permeable (RGP) – to include standard RGPs and Scleral contact lenses
    c. Hybrid Contact Lenses -- RGP center attached to an outer "skirt" made of soft contact lens material
6. Cleaning versus disinfection terminology. For this paper, cleaning will refer to the removal of deposits, debris, and some germs from the surface of the lens. Disinfection will refer to the killing of germs/infectious agents on the surface of (and sometimes within) the lens.

Below is a chart of lenses with increased risk of infections, including some of the above assumption factors [15]:

TABLE 2. Modifiable factors known to increase the risk for contact lens–related eye infections mentioned in reports of patients with infectious keratitis (N = 1,075) — Food and Drug Administration's Medical Device Report Database, 2005–2015.

Risk factor*	No. (%)
Any modifiable risk factor	270 (25.1)
Extended wear†	121 (11.3)
Occasional sleeping in contact lenses	75 (7.0)
Overwear (i.e., longer than the prescribed period)	85 (7.9)
Using expired lenses or products	8 (0.7)
Storing lenses in tap water	9 (0.8)
Wearing lenses while swimming	10 (0.9)
Unspecified hygiene problem	12 (1.1)

* These categories are not mutually exclusive.
† Defined as routine wearing of lenses continuously or overnight, whether the use is prescribed or not.

Materials of the lens types will have characteristics that are sometimes favorable to some microbes over others and should be addressed. Factors such as age of the contact lens and water content, oxygen permeability, surface quality, and other transmission avenues will affect the lens safety and infectious risks. Below is a summary table of infections associated with different types of contact lenses[15]:

TABLE 1. Number and percentage of patients with contact lens–related eye infections (N = 1,075), by selected characteristics and outcomes — Food and Drug Administration's Medical Device Report Database, 2005–2015

Characteristic	No. (%)
Female sex (n = 960*)	637 (66.4)
Type or source of lens	
Daily disposables	36 (3.4)
Soft daily wear	615 (57.2)
Soft extended wear	381 (35.4)
Rigid gas permeable	43 (4.0)
Decorative or cosmetic lens†	33 (3.1)
Purchased from unlicensed source (i.e., flea market or costume shop)	16 (1.5)
Outcome	
Emergency department or urgent care clinic visit	130 (12.1)
Hospitalized	25 (2.3)
Eye damage§	213 (19.8)
Corneal transplant	47 (4.4)

* Sex was unknown for 115 patients.
† Decorative or cosmetic lenses can include any type of lens (i.e., daily disposables, soft daily wear, soft extended wear, or rigid gas permeable).
§ Having a central corneal scar or a decrease in visual acuity, or requiring a corneal transplant.

Solutions used and some handling/cleaning mechanisms (rubbing when cleaning) will also factor into transmission. Ocular irritation due to use of a chemical disinfection method should be considered. Even though patients won't be caring for clinical multi-patient contact lenses, outlined below is a brief review of solutions and the terms used for *patient's* solutions/products for contact lenses.

Patient Cleaning, Disinfecting and Storage Solutions and Terminology[16]

1. Multipurpose Solution

Multipurpose solution is an all-in-one care system used to clean, rinse, disinfect, and store soft contact lenses. This solution is the most commonly used care system among soft contact lens wearers. Patients should follow these steps for proper use of multipurpose solution:

- Rub and rinse contact lenses and store them in fresh solution every time they are removed.
- Never mix fresh solution with old or used solution in the case—a practice called "topping off"—since it reduces the effectiveness of disinfection.
- Rub and rinse contact lens storage case with fresh solution—never water—daily.
- Empty all excess solution out of the case, and dry it with a fresh, clean tissue.

- Store the clean case upside down on a fresh, clean tissue with the caps off after each use in a clean, dry environment in order to prevent germs from building up in the case.

2. Hydrogen peroxide-based systems

Hydrogen peroxide-based systems clean, disinfect, and store contact lenses. Systems that use this type of solution require the use of a special case that reacts with the hydrogen peroxide, converting it to harmless saline solution over time. The bottle's red tip reminds the patient to never put the solution directly in the eye. Patients should follow these steps for proper use of hydrogen peroxide-based solutions:

- Carefully follow all instructions on the label for proper use of hydrogen peroxide-based systems
- Place the contact lenses in the special case with fresh solution. Never mix fresh solution with old or used solution.
- Wait, at minimum, 4 to 6 hours—depending on the label's instructions—before inserting contact lenses.
- Never rinse contact lenses with hydrogen peroxide-based solutions and never directly insert the solution into the eye, as this can cause burning, stinging, and redness.

3. Saline

Saline solution does not disinfect contact lenses. Saline is used to rinse contact lenses after cleaning and disinfecting with another care system.

4. Daily Cleaners

Daily cleaner is intended for cleaning—not disinfecting—contact lenses. The cleaner loosens and removes deposits and debris from the contact lens. Patients should use the daily cleaner and carefully rub the contact lens as instructed, and must use additional products, such as multipurpose solution, for rinsing the daily cleaner off, disinfecting, and storing the contact lenses.

5. Enzymatic Protein Removers

Enzymatic protein removers clean off material that eyes deposit on the contact lenses over time. Depending on the type of contact lenses and the amount of deposits that build up on the lens surface, additional products may be used for removing buildup. Enzymatic protein removers are available in liquid and tablet forms and are used on a daily or weekly basis depending on the product.

6. RGP Care Systems

Care systems for RGP, or hard contact lenses are different from care systems used with soft contact lenses. Hard contact lenses typically require several different solutions for wetting, cleaning, and disinfecting. Never use hard contact lens care products on soft contact lenses.

In November 2007, the Institute for Eye Research (IER) conducted a series of tests to evaluate the efficacy of various regimens that might be recommended for hygienic lens care.[17] In the IER study across four solutions and three lens types, in most cases, the addition of the 'rub and rinse' step significantly reduced the microbial load on the lens. This study has demonstrated that rubbing - combined with rinsing and appropriate time for disinfection - adds a significant safety margin (up to 100,000 times), compared to rinsing only:

1. Pseudomonas aeruginosa was reduced by a further two to three log units with 'rub and rinse'.
2. Staphylococcus aureus was reduced by, at minimum, a further two log units with 'rub and rinse'.
3. Both fungi Fusarium solani and Candida albicans were reduced by a further one to two log units with 'rub and rinse'.
4. Acanthamoeba polyphaga was reduced by up to a further 0.5 log unit with 'rub and rinse'.

Clinical Setting Best Practices of Multi-Use/Multi-Patient Disinfecting Regimens

This section will cover acceptable disinfection regimens for contact lenses used in the clinical setting. Most regimens will be generic to infectious agents and/or list the agents most susceptible to the disinfection method.

CDC Guidelines for the Provider (specifically HTLV-III/LAV but applying to listed diseases with the exception of Prion)[18]

1. Health-care professionals performing eye examinations or other procedures involving contact with tears should wash their hands immediately after a procedure and between patients. Handwashing alone should be sufficient, but when practical and convenient, disposable gloves may be worn. The use of gloves is advisable when there are cuts, scratches, or dermatologic lesions on the hands. Use of other protective measures, such as masks, goggles, or gowns, is not indicated.

2. Instruments that come into direct contact with external surfaces of the eye should be wiped clean and then disinfected by: (a) a 5- to 10-minute exposure to a fresh solution of 3 percent hydrogen peroxide; or (b) a fresh solution containing 5,000 parts per million (mg/L) free available chlorine, a 1/10 dilution of common household bleach (sodium hypochlorite); or (c) 70 percent ethanol; or (d) 70 percent isopropanol. The device should be thoroughly rinsed in sterile solution and dried before reuse.

3. Contact lenses used in trial fittings that are not disposable should be disinfected between each fitting by one of the following regimens:

    a. Disinfection of trial hard lenses should be performed with a commercially available hydrogen peroxide contact lens disinfecting system currently approved for contact

lenses. (Other hydrogen peroxide preparations may contain preservatives that could discolor the lenses.) Alternatively, most trial hard lenses can be treated with the standard heat disinfection regimen used for soft lenses (78-80 C (172-176 F) for 10 minutes). Practitioners should check with hard lens suppliers to ascertain which lenses can be safely heat-treated. Tap water should be avoided at all times due to potential Acanthamoeba contamination found in most municipal drinking water supplies.

b. RGP diagnostic/trial fitting contact lenses can be disinfected using the above hydrogen peroxide disinfection system. RGP lenses may warp if they are heat-disinfected.

c. Soft diagnostic/trial fitting lenses can be disinfected using the same hydrogen peroxide system. Some soft lenses have also been approved for heat disinfection. Other than hydrogen peroxide, the chemical disinfectants used in standard contact lens solutions have not yet been tested for their activity against HTLV-III/LAV. Until other disinfectants are shown to be suitable for disinfecting HTLV-III/LAV, contact lenses used in the eyes of patients suspected or known to be infected with HTLV-III/LAV are most safely handled by hydrogen peroxide disinfection.

4. Cleaning and disinfecting contact lens storage cases is also important. The American Optometric Association recommends you replace your contact lens storage case at least every three months or sooner if recommended by the manufacturer[19]. Discard the old solution from the wells of the case. Rub the case for at least five seconds, rinse with contact lens disinfecting solution, and then wipe dry with a clean tissue[20]. Air dry the case face down on a tissue with the caps off[21]. Avoid washing the case with tap water as this has been linked with an increased risk of infection[22].

Prion Disease Considerations

Prion cannot be destroyed by boiling, alcohol, acid, standard autoclaving methods, or radiation. Knowing that Prion transmission is very rare, it does not make economic sense for clinics to dispose of clinical instruments and/or any non-disposable contact lens used for multi-patient purposes. As we learn more about Prion, health care centers may look to the development of disposable covers, shields, and other methods of protecting patients from used instruments. If a clinician suspects Prion or the patient discloses their Prion disease, one should refrain from fitting the person with contact lenses and use all precautions to sterilize equipment and protect further patients and staff from contacting unsterilized surfaces.

Other methods studied, but not yet 100% effective in eliminating prion from surfaces[23]:

In vivo surface results with prions: tests

Test conditions		Total death/total tested	% transmission	Incubation time (mean ± SD)	Estimated $\log_{10}$ reduction[a]
Cleaning	Disinfection/sterilization				
Prolystica 2X Enzymatic 0.4%, 50 °C, 15 min	N/A	8/8	100	107 ± 6	<1
Prolystica 2X Enzymatic 0.4%, 50 °C, 30 min	N/A	8/8	100	110 ± 8	1–2
Prolystica 2X Enzymatic 0.4%, 50 °C, 5 min	Disinfection at 90 °C, 2 min	8/8	100	105 ± 4	<1
Prolystica 2X Enzymatic 0.4%, 50 °C, 15 min	Steam sterilization at 134 °C, 4 min	4/7	57	294 ± 83	4.4 (3.5–5.0)
Hamo-100 0.8%, 43 °C, 7.5 min	N/A	0/7	0	>540	>4.9
Hamo-100 0.4%, 55 °C, 5 min	N/A	4/7	57	208 ± 77	4.4 (3.5–5.0)
Hamo-100 0.2%, 55 °C, 5 min	N/A	8/8	100	193 ± 78	2.8
Hamo-100 0.2%, 55 °C, 5 min	Steam sterilization at 134 °C, 4 min	0/5	0	>540	>5.1
ProKlenz-One 0.8%, 25 °C, 10 min	N/A	0/6	0	>365	>5.1
Prolystica 10X Alkaline 0.16%, 65 °C, 2 min	N/A	2/5	40	313 ± 160	4.8 (4.2–5.7)
Prolystica 10X alkaline 0.16%, 65 °C, 2 min	Steam sterilization at 134 °C, 4 min	0/3	0	>540	>5.1
Prolystica 10X Alkaline 0.08%, 65 °C, 5 min	N/A	8/8	100	113 ± 15	2.0
Prolystica 10X alkaline 0.08%, 65 °C, 5 min	Steam sterilization at 134 °C, 4 min	0/6	0	>540	>5.1
Valsure Alkaline 2.4%, 65 °C, 5 min	N/A	6/6	100	322 ± 114	
Valsure Alkaline 2.4%, 65 °C, 5 min	Steam sterilization at 134 °C, 4 min	0/8	0	>540	>5.1
Prolystica 2X alkaline 0.4%, 65 °C, 5 min	N/A	8/8	100	118 ± 9	2.1
Prolystica 2X alkaline 0.4%, 65 °C, 5 min	Steam sterilization at 134 °C, 4 min	2/7	29	395 ± 18	4.9 (4.5–5.6)
N/A	V Pro 1 half-cycle (lumen cycle)	1/10	10	370	5.3 (4.9–6.7)
Prolystica 2X Alkaline 0.4%, 65 °C, 5 min	V Pro 1 (non-lumen cycle)	0/9	0	>520	>5.6

Future Possibilities for Prion Disinfection

Ultraviolet (UV)-ozone treatment reduces levels of the pathogenic Prion protein and inactivates the infectious agent. UV-ozone treatment has been shown to decrease the carbon and Prion protein content in infected brain homogenate to levels undetectable by dry ashing carbon analysis or immunoblotting, respectively. After eight weeks of ashing, UV-ozone treatment reduced the infectious titer of treated material by a factor of at least 10^5. A small amount of infectivity, however, persisted despite UV-ozone treatment.[24] It should be noted that UV radiation damages many polymeric materials, causing polymer chain scissions, and therefore such cleaning protocols may be

unsuitable for some biomedical devices[25] Other lasers and UV-ozone treatment devices may be developed specifically for Prion, but time will tell.

Air plasma offers a surface cleaning process and compared with hydrogen peroxide (H_2O_2) is more effective for removing hydrophobic surface contaminants. Typically, mixtures of non-toxic gases such as oxygen, nitrogen, argon, or hydrogen are used to generate such plasmas, for example O2/N2 and Ar/O2/N2 mixtures have been shown to be effective in removing biomolecules such as proteins from model surfaces. Removal of highly adherent pyrogens such as endotoxins might be a possibility with such plasmas, thus offering a tool capable of eliminating the complete pathogenic bioburden from surfaces. A complete air plasma cleaning cycle takes less than 30 minutes. Air plasma cleaning can be viewed as an ablation/ashing technique, where the surface contaminant is removed as molecular fragments after plasma cleavage of bonds within molecules, irrespective of how the contaminant is attached to the surface.[26] In the case of prion proteins, however, appropriate quarantine measures must be put in place before undertaking the cleaning process and more study is needed.

Other Documents for Consideration

The International Organization for Standardization (ISO) has addressed multi-patient contact lens use and disinfection in **ISO 19979:2018(E).**

The American Optometric Association was denied permission to include the document in this educational brief without paying a royalty fee for each downloaded copy of this brief. Practitioners who wish to purchase the document should access the ISO/ANSI site: https://www.iso.org/home.html

Conclusion

Providers should take every precaution to limit multi-patient contact lens transmission of disease by educating themselves and their staff on best practices for disease control. This includes the techniques of hand washing, gloving, disinfection of instruments, contact lenses, storage cases, and management of in-office contact lens solutions. For other helpful information, please go to: https://www.cdc.gov/infectioncontrol/guidelines/disinfection/index.html

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