

Sterilization and Disinfectants Used in a Dental Office- a Review

S.KishoreKumar¹, T.Shoba², Prashanth Sreenivasan³

¹Vice Principal and Assistant Director (R&D), Department of Orthodontics and Dentofacial Orthopedics, ²Prof and Head , Department of General Pathology, Sree Balaji Dental Colege and Hospital, Bharath Institute of Higher Education and Research, Chennai, Tamil Nadu, India, ³Senior Lecturer, Department of Orthodontics and DentofacialOrthopedics, Tagore Dental College and Hospital, The Tamil Nadu Dr. M.G.R. Medical University, Chennai, Tamil Nadu, India

Abstract

As dentists, we must disinfect and clean all equipments and countertops between patients with a recommended hospital-grade bactericidal product. Nonvisible blood and saliva does not mean it is absent on environmental surfaces. Blood and saliva are present throughout dental treatment. If a patient becomes ill as a result of an exposure to a pathogen or a bacterium that is later found in our dental office surfaces, the employer and or dentist is at risk of being responsible for the patient's illness and associated compensatory damages. Understanding and recognizing the risk of disease will drastically reduce patient illness, practice liability and employee illnesses. Dentists cannot pretend that this is only a theoretical problem. Therefore the dental community needs to stay updated of the rapidly evolving standard of care and do its best to comply with the standard of care in daily practice.

Key Words: Sterilization, Chemical Disinfection, Fumigation, Pathogens.

Introduction

Sterilization is the killing or removal of all microorganisms, including bacterial spores which are highly resistant. Sterilization is an absolute term, i.e. the article must be sterile meaning the absence of all microorganisms'

Disinfection is the killing of many, but not all microorganisms. It is a process of reduction of number of contaminating organisms to a level that it prevents infection that is, all pathogens must be killed. Some organisms and bacterial spores may survive¹.

Breaking the chain of infection would be an avenue in reducing the spread of infectious disease. Hands touch many objects throughout the day and germs are easily transferred to surfaces, causing cross-contamination. Bacteria will not survive inside the material/clothing. Sneeze into the sleeve, covering both the nose and the mouth. Another way to break the chain of infection is through frequent hand washing.

The four following things are necessary for infection to occur:

- The presence of a pathogen (infection causing agent) in sufficient quantity to lead to infection
- Multiple source of infection are: human waste, animal waste, insect waste, environmental waste.
- An entry point or mode of transmission examples are: an open wound
- A person's (host's) susceptibility to the pathogen

Certain surfaces, that too the ones touched often (e.g., light handles, unit switches, and drawer knobs) can serve as reservoirs of microbial contamination, although they have not been linked directly with spread of infection to either dental health-care professionals (DHCP) or patients. Cleaning and disinfecting environmental surfaces plays a major role in patient's health in any dental facility. Microorganism transfer from contaminated environmental surfaces to patients

occurs primarily through Dentists hand contact. When surfaces are touched, microbial agents can be transferred to the patients or other workers or to the dental office environment or dental instruments. Although hand hygiene is key to minimize this type of transfer, disinfecting and cleaning of environmental surfaces also protects against health-care-associated infections.

Environmental surfaces are divided into housekeeping surfaces and clinical treatment surfaces. Surfaces such as floors, walls, and sinks are housekeeping surfaces and have limited risk of disease transmission. Action plan for cleaning and disinfecting surfaces in patient care areas should have written standard operating procedures that consider the following:

- The potential for direct patient contact
- The degree and frequency of hand contact
- Potential contamination of the surface with environmental sources or body substances containing microorganisms.

Cleaning is the necessary first step of any disinfection protocol. Cleaning is a form of decontamination that renders the environmental surface safe by removing organic material and visible soils, all of which interfere with microbial inactivation. If a surface has not been cleaned first, the success of the disinfection process can be compromised. If a surface cannot be cleaned adequately, it should be protected with barriers. Barrier protection of surfaces and equipment and small buttons or switches can prevent contamination of clinical surfaces including those hard to clean.

When barriers are not being used, surfaces should be cleaned first, then disinfected between patients using an EPA-registered hospital disinfectant with an HIV, HBV claim (low-level disinfectant) or a tuberculocidal claim (intermediate-level disinfectant). An intermediate-level disinfectant should always be used when a surface is visibly contaminated with blood or other potentially infectious material (OPIM). As stated earlier in this article, environmental surfaces can become contaminated via sneezing and coughing, which can contaminate work surfaces. This, in turn, can cause the transmission of disease. Potentially infected bacteria or blood and saliva cannot always be seen. Treatment areas should be kept

free from clutter (e.g., papers, supplies, and equipment) to expedite cleaning and disinfecting treatment areas between patients.²

Mycobacterium TB (Mtb) has been a benchmark for years in dentistry. Mycobacterium TB is a bacterium that is hard to kill because of its cell wall, which is 60% lipid. This TB bacterium is an aerobe; to survive it needs oxygen and can withstand weak disinfectants and survive in a dry state for weeks. TB is transmitted via an airborne route. Potency against Mtb has been recognized as a substantial benchmark to measure germicidal potency. Mycobacterium has the highest intrinsic levels of resistance among the vegetative bacteria, viruses, and fungi; germicides with a tuberculocidal claim on disinfectant labels are considered capable of inactivating a broad spectrum of pathogens, including such less-resistant organisms as blood borne pathogens (e.g., hepatitis B virus, hepatitis C virus, and HIV).³

Each dental practice has different types of clinical surfaces: contaminated instruments, contaminated bib holders, hands, gloves, protective eyewear/face shields, and masks directly touch these surfaces.

Discussion

1. Chemical Disinfectant Groups

a. Aldehydes: (Formaldehyde, Paraformaldehyde, Glutaraldehyde)

Formaldehyde – and its polymerized solid paraformaldehyde have broad-spectrum biocidal activity and are both effective for surface and space decontamination. As a liquid (5% concentration), formaldehyde is an effective liquid decontaminant. Its biocidal action is through alkylation of carboxyl, hydroxyl and sulfhydryl groups on proteins and the ring nitrogen atoms of purine bases. Formaldehyde's drawbacks are reduction in efficacy at refrigeration temperature, its pungent, irritating odor, and several safety concerns. Formaldehyde is presently considered to be a carcinogen or a cancer-suspect agent according to several regulatory agencies. The OSHA 8-hour time-weighted exposure limit is 0.75 ppm.

Paraformaldehyde – is a solid polymer of formaldehyde. Paraformaldehyde generates formaldehyde gas when it is depolymerized by heating to

232 to 246°C (450 to 475°F); the depolymerized material reacts with the moisture in the air to form formaldehyde gas. This process is used for the decontamination of large spaced and laminar-flow biological safety cabinets when maintenance work or filter changes require access to the sealed portion of the cabinet. A neutralization step, heating ammonium carbonate, is required prior to ventilation of the space. Formaldehyde gas can react violently or explosively (7.0 – 73% v/v in air), when exposed to incompatibles, therefore, only individuals that have specific training and have been approved by the Dept. of Environmental Health & Safety are permitted to use this gas.

Glutaraldehyde – is a colorless liquid and has the sharp, pungent odor typical of all aldehydes, with an odor threshold of 0.04 parts per million (ppm). It is capable of sterilizing equipment, though to effect sterilization often requires many hours of exposure. Two percent solutions of glutaraldehyde exhibit very good activity against vegetative bacteria, spores and viruses. It is ten times more effective than formaldehyde and less toxic. However, it must be limited and controlled because of its toxic properties and hazards. It is important to avoid skin contact with glutaraldehyde as it has been documented to cause skin sensitization. Glutaraldehyde is also an inhalation hazard. The NIOSH ceiling threshold limit value is 0.2 ppm.

Cidex, a commercially prepared glutaraldehyde disinfectant is used routinely for cold surface sterilization of clinical instruments. Glutaraldehyde disinfectants should always be used in accordance with the manufacturer's directions.⁴

b. Halogen-Based Biocides: (Chlorine Compounds and Iodophores)

1. Chlorine Compounds

Chlorine compounds are good disinfectants on clean surfaces, but are quickly inactivated by organic matter and thus reducing the biocidal activity. They have a broad spectrum of antimicrobial activity and are inexpensive and fast acting. Hypochlorites, the most widely used of the chlorine disinfectants, are available in liquid (e.g., Sodium hypochlorite), household bleach and solid (e.g., calcium hypochlorite, sodium dichloroisocyanurate) forms. Household bleach has an

available chlorine content of 5.25%, or 52,500 ppm. Because of its oxidizing power, it loses potency quickly and should be made fresh and used within the same day it is prepared. The free available chlorine levels of hypochlorite solutions in both opened and closed polyethylene containers are reduced to 40% to 50% of the original concentration over a period of one month at room temperature.

There are two potential occupational exposure hazards when using hypochlorite solutions. The first is the production of the carcinogen bis-chloromethyl ether when hypochlorite solutions come in contact with formaldehyde. The second is the rapid production of chlorine gas when hypochlorite solutions are mixed with an acid. Care must also be exercised in using chlorine – based disinfectants which can corrode or damage metal, rubber, and other susceptible surfaces. Bleached articles should never be autoclaved without reducing the bleach with sodium thiosulfate or sodium bisulfate.⁵

Chloramine T which is prepared from sodium hypochlorite and p-toluenesulfonamide is a more stable, odorless, less corrosive form of chlorine but has decreased biocidal activity in comparison to bleach.

2. Iodophors

Iodophors are used both as antiseptics and disinfectants. An iodophor is a combination of iodine and a solubilizing agent or carrier; the resulting complex provides a sustained-release reservoir of iodine and releases small amounts of free iodine in aqueous solution. Antiseptic iodophors are not suitable for use as hard-surface disinfectants because they contain significantly less free iodine than do those formulated as disinfectants.

Wescodyne, *Betadyne*, Povidone-Iodine and other iodophors are commercially available Iodine-based disinfectants, which give good control when the manufacturer's instructions for formulation and application are followed. Both bleach and iodophors should be made up in cold water in order to prevent breakdown of the disinfectant.⁶

c. Quaternary Ammonium Compounds: (Zephirin, CDQ, A-3)

Quaternary ammonium compounds are generally

odorless, colorless, nonirritating, and deodorizing. They also have some detergent action, and they are good disinfectants. However, some quaternary ammonium compounds activity is reduced in the presence of some soaps or soap residues, detergents, acids and heavy organic matter loads. They are generally ineffective against viruses, spores and *Mycobacterium tuberculosis*. Basically these compounds are not suitable for any type of terminal disinfection.

The mode of action of these compounds is through inactivation of energy producing enzymes, denaturation of essential cell proteins, and disruption of the cell membrane. Many of these compounds are better used in water baths, incubators, and other applications where halide or phenolic residues are not desired.⁷

d. Phenolics: (O-phenophenoate-base Compounds)

Phenolics are phenol (carbolic acid) derivatives. These biocides act through membrane damage and are effective against enveloped viruses, rickettsiae, fungi and vegetative bacteria. They also retain more activity in the presence of organic material than other disinfectants. Cresols, hexachlorophene, alkyl- and chloro derivatives and diphenyls are more active than phenol itself. Available commercial products are Lysol, Pine-Sol, *Amphyl*, *O-syl*, *Tergisyl*, *Vesphene*, *L-Phase* and *Expose*.⁸

e. Acids/Alkalis:

Strong mineral acids and alkalis have disinfectant properties proportional to the extent of their dissociation in solution. Some hydroxides are more effective than would be predicted from their values. In general acids are better disinfectants than alkalis. Mode of action is attributed to an increase of H⁺ and OH⁻ species in solutions which interfere with certain microbial functions, however the total effect is not only dependent on pH alone. Weak organic acids are more potent than inorganic acids despite low dissociation rates in solution. Action is attributed to the disruption of 2° and 3° conformation of enzymes and structural proteins^{9,10}.

f. Heavy Metals:

Soluble salts of mercury, silver lactate, mercuric chloride and mercurous chloride are efficient bactericidal agents. Silver nitrate and mercuric chloride

are commonly used as 1:1000 aqueous solutions. Action is through attack on protein sulfhydryl groups and disruption of enzyme functions. Organic matter can reverse the disinfectant properties of mercurials.

Caution: Please consult with EH&S's Hazardous Materials group prior to using heavy metals because many of these must be disposed of as a hazardous waste. Specifically, disposal of elemental mercury and salts of mercury are very costly.

g. Alcohols:

Alcohols work through the disruption of cellular membranes, solubilization of lipids, and denaturation of proteins by acting directly on S-H functional groups. Ethyl and isopropyl alcohols are the two most widely used alcohols for their biocidal activity. These alcohols are effective against lipid-containing viruses and a broad spectrum of bacterial species, but ineffective against spore-forming bacteria. They evaporate rapidly, which makes extended contact times difficult to achieve unless the items are immersed.

The optimum bactericidal concentration for ethanol and isopropanol is in the range of 60% to 90% by volume. Their cidal activity drops sharply when diluted below 50% concentration. Absolute alcohol is also not very effective. They are used to clean instruments and wipe down interior of Biological Safety Cabinets and bottles, etc. to be put into Biological Safety Cabinets. Alcohols are generally regarded as being non-corrosive.

Conclusion

High technology has provided dentistry with infection-control-friendly equipment. Cleankeys is a flat keyboard that saves time when cleaning and disinfecting any operatory or for the administrative staff. This style of keyboard eliminates worries about spilled liquids or food lodging in between the keys. This keyboard has a mouse included to guard against contamination and promote easy cleaning.

The Dental R.A.T. is a hands-free, voice-activated periodontal probing system designed by a dental hygienist to enhance care while reducing the risk of contamination. Please view the video on the dentalrat.com website for more information. This technology puts a whole new light on discovering periodontal disease.

Discover how quick and easy this technology can assist in a day's work.

Ethical Clearance – Not required since it is a review article

Source of Funding – Nil

Conflict of Interest – Nil

References

1. WHO GLOSSARY, 2005.
2. Manufacturing Chemists Association: *Laboratory Waste Disposal Manual*. Revised August 1975 MCA 1825 Connecticut Avenue, Washington DC 2009.
3. U.S. DHEW/P.H.S/NIH/NCI; *Effective use of the Laminar Flow Biological Safety Cabinet*; NCI, Bethesda, MD, 2007.
4. APIC (Association for Professionals in Infection Control and Epidemiology) "Guidelines for Selection and Use of Disinfectants" reprint from American Journal of Infection Control; August 1996, Vol. 24, No. 4, pp. 313-342.
5. Davis, B.D. Dulbecco, R., Eisen, H.N. et al ; *Microbiology*, Third Edition; Harper and Row; Hagerstown, MD (1980)
6. Joklik W.K., Willet, H.P.; *Zinsser Microbiology*; 18th Edition; Appleton Century- Crofts/ New York, 1984.
7. Block, S.S.; *Disinfection, Sterilization and Preservation*; 5th Edition Lippincott Williams & Wilkins; Philadelphia, (2000).
8. Pelczar, M.J. Reid, R.D., Chan, E.C.S.; *Microbiology*, 4th Edition; McGraw Hill Book Company, New York, (1977).
9. Kruse, R.H.; Puckett, William H.; "*Biological Safety Cabinetry*"; *Clinical Microbiological Reviews*; (1991) Vol 4 (2), pp 207-241; American Society for Microbiology, Washington, D.C.
10. WHO Infection Control Guidelines for Transmissible Spongiform Encephalopathies, Geneva, Switzerland, 23-26 March 1999.