Review Article

Role of high-efficiency particulate arrestor filters in control of air borne infections in dental clinics

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ABSTRACT

Infections in dental practice may be transmitted by several routes, including direct contact with blood, oral fluids, or other secretions, through indirect contact with contaminated instruments and surgical equipments, through contact with aerobiological contaminants present in either droplet spatter or the aerosols resulting from oral and respiratory fluids. Preventing the spread of air borne infection is gaining importance in dental set ups because a large number of bacteria and viruses are transmitted through this route and prove to be a health hazard for both patients and dental health care personnel. High-efficiency particulate arresting (HEPA) air filters are very effective in reducing bioaerosols, and hence, preventing air borne infection. This paper discusses the role of HEPA filters in controlling air borne infections in dental clinics.

Key words: Bioaerosols, high-efficiency particulate arrestor, infection control

INTRODUCTION

Infection control is the discipline concerned with preventing nosocomial or health care associated infections.[1] Infections in the dental surgery unit may be transmitted by several routes, including direct contact with blood, oral fluids, or other secretions, through indirect contact with contaminated instruments, surgical equipment, or environmental surfaces, or through contact with aerobiological contaminants present in either droplet spatter or the aerosols resulting from oral and respiratory fluids.[2] Infection through any of these routes requires that all three of the following conditions be present:

1. A susceptible host.
2. A pathogen with sufficient infectivity and in sufficient numbers to cause an infection.
3. A point of entry into the host.[3]

Most of the steps taken to control or prevent infection have succeeded in reducing infection by fluid transfer and contact. The most intangible means of pathogen transmission, that is, "air," is being increasingly recognized as a serious infection transmitting hazard in dental set up for dental health care personnel (DHCP) (dentists, hygienists, and dental lab technicians) and patients.[2,4]

STEPS FOR INFECTION CONTROL IN DENTAL SET UP

When a patient enters the dentist's room every effort must be taken to prevent infection or cross contamination. It includes thorough case history, oral examination, and various investigations which are carried out. A properly vaccinated dental team, proper hand washing, personal

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protective equipment which include gloves (latex gloves or vinyl gloves, general purpose utility gloves or surgeon's sterile gloves), gowns, face shields, hair protection, mouth masks (preferably with fluid shield), and goggles/eye wear are the other preventive steps toward infection control.[5] The objectives of infection control in dental setup are:

1. To protect the patients and members of the dental team from contracting infections during dental procedures.
2. To reduce the number of pathogenic microorganisms in the dental environment and during dental procedures, to the lowest possible level.
3. To implement a high standard of cross-infection control when treating every patient.[5]

AIRBORNE INFECTION IN DENTAL CLINICS

The role of the air as a carrier of infection is seen in tuberculosis, measles, severe acute respiratory syndrome, multi-resistant *Staphylococcus aureus*, influenza, legionnaires disease, pneumonia, mumps, chicken pox, cytomegalovirus infection, hepatitis B and C virus infection, herpes simplex virus Types 1 and 2 infection, human immunodeficiency virus, etc.[6-8] The dispersion of bacteria and viruses (reservoir being mouth with saliva, blood, subgingival fluids, and moisture from the nasopharynx) into the air due to coughing, sneezing, general exhalation, and exacerbated by the use of the high-speed instruments such as ultrasonic scalers and handpieces starts the chain of air-borne infection. During dental treatment, several thousand droplets are aerosolized.[9] The larger droplets fall quickly to the floor and onto other surfaces, the smaller droplets evaporate quickly, leaving dry microscopic droplet nuclei which remain suspended in the air for extended periods of time and require prolonged hours to settle down. The bacteria and viruses become highly mobile in the air. They circulate from one room to another by convection currents.[2,10,11] Microorganisms in excess of 5 times that of outdoor air are present in dental surgery units.[12] Four technologies that target the decontamination of air are:

1. Filtration or decontamination - Through high-efficiency particulate arrestor (HEPA) filters.
2. Ozonization — It subjects the air to high voltage charges. This results in the separation of adjacent oxygen atoms which brings about the creation of the ozone isotope. Ozone molecules are highly reactive and when they come into contact with microorganisms they react, rendering them harmless. However, the amount of ozone required to destroy pathogens in the air would present a health risk to dental personnel and patients.
3. Ionization - It uses charged electrodes to project negative ions into the air. The microorganisms floating in the air attract these negatively charged ions and become heavier as a result and then precipitate onto surfaces. However, the microorganisms are not destroyed through this process. They remain viable and thus require further treatment through some more conventional form of disinfection.
4. Air sterilization — By use of ultraviolet irradiation. The DNA of all bacteria and viruses are ruptured, thus, rendering them sterile and incapable of reproduction.[2,13]

HIGH-EFFICIENCY PARTICULATE ARRESTOR AIR FILTERS

Dental clinics/hospital air quality and ventilation play a decisive role in affecting air concentration of pathogens, and hence have a major effect on infection rates. Researchers have linked all of the following to air quality and infection rates: Type of air filter, direction of airflow and air pressure, air changes per hour in room, humidity, ventilation system changes, and maintenance. Filtration is the physical removal of particulates from the air and is a key step in achieving acceptable indoor air quality. It is also stated that to maintain the air cleanliness in operating room permanently, air exchange rate in the operating room should be more than 15 times in 1 h (15 times $\times$ h $[-1]$).[14] Air purifiers utilize different types of filtration such as carbon, HEPA, or a mixture such as a carbon/HEPA filtration unit. While a carbon filter is ideal for chemicals and odors in the air, HEPA is ideal for air particles. HEPA filters were developed in 1940's by the US Atomic Energy Commission to prevent the spread of airborne radioactive particles as part of the Manhattan Project. After World War II, HEPA filter technology was declassified and made available for commercial and residential use. Filtration unit depends on the amount of square feet that is to be cycled. According to the Institute of Environmental Sciences and Technology, a certified HEPA filter must capture a minimum of 99.97% of contaminants 0.3 microns in size and larger. This means that for every 10,000 particles that pass through the filter, only three can be permitted to escape.[15] These are being used now where exceptional air quality is required such as hospital operating and isolation rooms, the aerospace and pharmaceutical industries, and in nuclear and computer chip manufacturing plants around the world. HEPA filters are constructed from paper such as glass fiber or polymer sheets, which are pleated many times in a "V" pattern to maximize the surface area within a small volume to enhance their effectiveness in removing particles. The filters marketed as "HEPA-type," "HEPA-like," or "99% HEPA," do not meet the industry standard and are less effective at removing particles. HEPA filters decrease the concentration of airborne infectious pathogens in a room and prevent the spread of diseases such as tuberculosis, chicken pox, shingles, and measles. Apart from being an effective means of controlling air borne infection another advantage is that these filters do not produce ozone.[9]

ADVANTAGES OF HIGH-EFFICIENCY PARTICULATE ARRESTOR AIR FILTERS

1. Reduce allergy and asthma triggers, harmful chemicals, gases, and odors in the air.
2. Protect from harmful volatile organic compounds and microbiological contaminants.
3. Protect from nitrous oxide which can cause mild disorientation to long-term health hazards for staff if the room is improperly ventilated. The permissible exposure limit for nitrous oxide in the workplace is 25 parts per million, averaged over an 8 h work day.
4. Protect from mercury vapors resulting from exposure during amalgam fillings and removals. The mercury from these vapors can quickly travel to the kidneys, liver, intestines, heart, brain, and other organs causing serious chronic health issues.
5. Protect from bioaerosols (e.g., organic dust consisting of pathogenic or nonpathogenic live or dead bacteria and fungi, viruses, bacterial endotoxins, mycotoxins, peptidoglycans, high molecular weight allergens, pollen, plant fibers, etc.), which may lead to adverse effects on respiratory function and cause lung function impairment
6. Trap the *Aspergillus* fungus spores inside the filter, thus, beneficial to asthmatic patients.
7. Removal of tuberculosis bacilli from air (tuberculosis containing droplet nuclei are approximately 1-5 microns in diameter).
8. Reduce risk of heart disease and improve cardiovascular health.[15,16]
9. One disadvantage is that the filter may become a source of microbes if those retained microorganisms proliferate and re-entrain back into the filtered air. However, this problem can be handled effectively by using photocatalytic reactions to inactivate those confined microorganisms.[17]

CONCLUSION

Infection control in dental practice is an important issue and any lapses in it could be detrimental to the health of both patients and DHCP. Control and prevention of spread of air borne infection are gaining importance in dental set ups because a large number of bacteria and viruses are transmitted through this route. Due to their highly effective technology in reducing the level of bioaerosols and other advantages HEPA filters prove to be an exceptional means of controlling air borne infections in dental clinics, and hence, provide better indoor air quality.

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Conflicts of interest

There are no conflicts of interest.

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