Review Article

Changing face of infection control: Dental unit water lines

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The quality of dental unit water is of considerable importance since patients, staff are regularly exposed to water and aerosols generated from the unit. The contamination of dental unit waterlines (DUWL) is an issue that is of great concern to the dental profession, including Prosthodontics since the water in these lines has the capacity for rapid development of biofilms combined with the generation of potentially contaminated aerosols becoming an ideal environment for the growth of microorganisms. This article describes the conditions in waterline tubing that favour development of biofilms and discusses the level of risk that such microbial growth poses for both dental professionals and their patients. It is stressed that very few cases of infection have been linked directly to contamination in dental unit waterlines. Finally, potential solutions for minimizing risks are presented and discussed.

Key words: Dental unit water lines, disinfection, sterlisation

INTRODUCTION

Identifying all possible transmission routes of infectious agents is a key element of any infection control protocol. In dentistry of particular concern are those devices that are placed within the oral cavity and that are not easily or routinely disinfected because of their design or some other consideration.[1]

Dental hand pieces (specifically high-speed drills), air/water syringes, routinely used for Fixed Denture Prosthodontics and other dental work, and ultrasonic scalers are connected to dental units by a network of small-bore plastic tubing through which water and air are propelled to activate or cool down the instruments. Hydrodynamics shows that the water column inside a small lumen moves in the centre of the tubing, leaving a thin layer of liquid virtually undisturbed along the walls. Coupled with recurrent long-term water stagnation (over nights, weekends and holidays) at warm temperatures, this physical state creates conditions for water micro flora to establish tenacious adherent communities. Some dental unit waterlines that have been in use for many years are coated with a biofilm that is visible to the naked eye, clogs the small-bore tubing and gives the water a foul odour.[2] Biofilm is defined as a mass of microorganism attached to a surface exposed to moisture and they form just anywhere there is a moist non sterile environment.[3] This includes the surfaces associated with natural water environment and also on biomedical materials implanted in or associated with the human body, including many types of medical catheters, sutures, wound drainage tubes, endotracheal tubes, mechanical heart valves, and intrauterine contraceptive devices. The best example of biofim in dentistry is dental plaque. Thus there is a type of plaque that develops inside of dental unit waterlines that causes a permanent infection of the water delivery system.[3] This article describes the conditions in waterline tubing that favour development of biofilms and discusses the level of risk that such microbial growth poses for both dental professionals and their patients.

Quality of water in dental unit water lines

Water with less than 1 fecal coliform/100 mL and less than 500 colony-forming units (CFU)/mL is considered potable.[2] Because the detection of coli form bacteria is impaired by high bacterial loads, it has been argued that total bacterial counts higher than 500 CFU/mL might conceal the presence of some pathogens in a sample. The extent of bacterial contamination of dental unit water lines (DUWL) has consistently found to be above that recommended for domestic supplies.[4] Water delivered through dental

hand pieces has much higher microbial counts, sometimes as high as 200,000 CFU / mL. Water entering the dental unit usually has a very low number of microorganisms present but the water that passes out of the dental unit through hand pieces, scalers, and air water syringes is highly contaminated.[3] Thus the incoming water becomes highly contaminated when inside the dental unit. One of the reasons for these high concentrations may be the high area-to-volume ratio of small-bore waterlines (6:1), which offers plenty of surface area on which the microorganisms can settle and a relatively small volume of liquid into which daughter cells can be shed.[2] The other being the contamination that comes from biofilm attached to the inside of the dental unit waterlines.[3] Most dental units are connected directly to municipal distribution systems for potable water; even if chlorinated; this water hosts a diverse micro flora of bacteria, yeasts, fungi, viruses, protozoa, unicellular algae and nematodes. Free-floating (planktons) microorganisms are vulnerable to environmental stress, biocide activity and microscopic predators. However, once inside the dental unit, such microorganisms can settle on the inner tubing surface, initiating a chain of events that results in colonization, micro colony formation and, eventually, biofilm development. A number of different microorganisms have been found to contaminate DUWL, which include coliforms, Gram positive rods, nonhaemolytic streptococci, enterococci, Moraxella, and Legionella.[5] Most of these microorganisms detected are of very low pathogenicity, or are opportunistic pathogens, causing harmful infections only under special conditions or in immunocompromised persons. Microorganisms of main concern are species of Pseudomonas, Legionella and Mycobacterium.[3]

Types and importance of microorganisms in dental unit water

Most of these microorganisms detected are of very low pathogenicity, or are opportunistic pathogens, causing harmful infections only under special conditions or in immunocompromised persons. Microorganisms of main concern are species (sp) of Pseudomonas, Legionella and Mycobacterium. The presence of biofilms inside waterlines tends to be associated with higher baseline levels of the above opportunistic pathogens in the water exiting the waterline. *P. aeruginosa* may be isolated from 15% to 24% of samples of dental unit water at concentrations of up to 2 x 10^5 CFU / mL and may account for 75% to 100% of the cultivated flora in these units.[2] Legionella sp. is regularly isolated from dental unit waterlines, where they can reach concentrations of 10^2 to 10^4 CFU / mL.[2] The occurrence of these organisms could be due to the presence in waterlines of free-living amoebae, which are considered important hosts for *L. pneumophila* and other pathogenic bacteria, including *P. aeruginosa*. Nontuberculous mycobacterium (including Mycobacterium gordonae and Mycobacterium chelonae) reach concentrations in dental unit water that are 400 times greater than those in tap water.[2] Thus, biofilms may be an important site for the growth of aquatic mycobacterium.[2] There are at least 4 ways in which waterborne microorganisms might cause infection in a patient undergoing dental work: hematogenous spread during surgical procedures, local mucosal (oral or conjunctival) contact, ingestion and inhalation. Hematogenous dissemination is considered theoretical but possible. Dental treatment can lead to transient bacteremia caused by oral streptococci. However, involvement of oral tissue is more likely, possibly through local infection after tooth extraction or periodontal intervention. Eye infection with Acanthamoeba spp. after accidental splatter has been reported.[2] Gastrointestinal disorders caused by waterborne microorganisms, although possible, would be difficult to link to a dental unit.[2]

The evidence suggests that dental personnel are continually exposed to waterborne microorganisms. For example, the prevalence of antibodies to *L. pneumophila* was significantly higher among dental personnel than in a control population (34% and 5% respectively. While there do not seem to have been any studies examining the presence of waterborne bacteria in the air of a dental clinic, some findings suggest that they may be present and viable, although not cultivable.[2] There is thus a theoretical risk of infection associated with the microbial organisms found in dental unit waterlines.

Pseudomonas

Pseudomonas aeruginosa and *P.cepacia* are common inhabitants of our environment, existing in soil and natural water *P.cepacia* is an important respiratory pathogen in patients with cystic fibrosis. *P.areuginosa* is usually opportunistic in causing urinary tract infection, wound infection, pneumonia and septicemia in burn patients and it along with *P.cepacia* has a higher degree of resistance than many bacteria to killing by disinfecting chemicals and by antibiotics. The only scientific report that directly implicates any microorganism from dental unit water as a health risk has involved Pseudomonas aeruginosa as a cause of oral infection in two medically compromised patients.[3] In a 1990 civil suit against a dental unit manufacturer, the plaintiff claimed that bacterial endocarditis and the need for subsequent prosthetic heart valve surgery resulted from dental treatment with contaminated water.[7]

Legionella

Legionella pneumophila and the other species of gram negative bacteria, naturally occurs in water. They may gain some protection against the chlorine present in domestic water because they exist inside certain free living amoeba also present in the water, *L. pneumophila* is the causative agent of a type of pneumonia called legionnaires disease. The bacterium is usually transmitted by inhalation of aerosolized or contaminated water by aspiration of organisms that have colonized the oro-pharynx.

Legionella species may be present in some dental unit water; however there is no documentation of dental unit water having caused legionairres disease in patients or in dental team members. However, a comment about unpublished data in a report about Legionella in dental unit water infers that a dentist in California who died of legionellosis may have contracted the causative agent from his dental unit water.[3]

Control of microorganisms in duwl

A report from England showed that two cancer weakened dental patients acquired oral infections with Pseudomonas aeruginosa that originated from dental unit water, the same study also showed that an additional 78 patients treated at the same dental unit were orally colonized for 4-10 weeks by the *P.aeruginosa* present in the dental unit water.[3]

However none of these patients developed harmful infections with the Pseudomonas presumably because they were not cancer weakened or otherwise compromised. *P.aeruginosa* is a very important opportunistic pathogen and the American Dental Association and the Centre for Disease Control and Prevention (CDC) indicate that[3] dental unit water should not be used to irrigate surgical sites exposing bone.

Water lines should be flushed at the beginning of the day to temporarily reduce the number of waterborne bacteria that may have accumulated in the water overnight.

Water lines should be flushed between the patients to reduce the number of oral microorganisms that may have retracted into the lines after each patient.

Thermal control of legionella[6]

Avoid storage of water between 20-45^0 C

If hot water plumbing is available should be stored at 60^0 C. However beware of causing scalds, use notice stating "Be Careful, Very hot water"

Infrequently used taps should be flushed for several minutes on a weekly basis.

Mycobacterium

Non tuberculous mycobacterium (Mycobacterium chelonae) has been detected in domestic water supplies. They are somewhat resistant to chemical killing and have caused infections in dialysis patients and have been detected in water used to process dialyzers.

Other bacterium

Acinetobacter, Alcaligenes, Klebsiella and Serratia are all gram negative bacteria that may cause harmful opportunistic pathogens that may cause harmful infections in compromised host. No specific documentation exists that these bacteria from dental unit water have caused any infections in patients or in dental team members.

Biolfilms in dentalunit waterlines

Microorganisms exist in DUWL in two types of communities. One bacterial community exists in the water itself and is referred as to as the planktonic (free floating) microorganisms. The other exists in a sessile form attached to the inside walls of the waterlines called biofilm.

Mechanism of biofilm formation

Biofilms form when bacterial cells adhere to a surface using cell surface polymers. Many of these polymers are highly hydrated exopolysaccharides, referred to as glycocalyx polymers that give the biofilm a slimy nature. As the attached cells multiply within the glycocalyx, the new cells remain embedded and form micro colonies on the surface. Continual multiplication results in the joining of micro colonies and this results in covering of the surface.

Factors that influence the formation of duwl biofilm[3]

1. Water stagnation
   a. Water in the tubing is not under high pressure.
   b. Water flow in the lines is low near the walls of the tubing.
   c. Small diameter tubing creates large surface to volume ratio.
2. Even though bacteria are usually at low levels in the incoming water, they are continually present, providing the pioneer bacteria for biofilm formation.
3. Some bacteria in air or in patient materials may enter the DUWL system through the contamination of waterline openings or retraction through the hand piece or water air syringe.
4. Water borne bacteria entering the system have special abilities to attach to the surface, facilitating biofilm formation.
5. Incoming bacteria bring about a continuous source of nutrient to the bacteria in the developing biofilm.
6. Biofilm that attach to tubing walls or to other attached bacteria multiply to increase the mass of the

biofilm.

7. As water flows by the biofilm, it picks up bacteria from the biofilm and carries it through hand piece, air water syringe, scalers and cup fillers.

The need to improve dental unit water quality

The goal of infection control is to eliminate or reduce exposure to microorganisms. Although there is no evidence of any widespread public health problems from exposure to dental unit water, use of such water that is contaminated with microorganisms of any kind for dental treatment is contrary to the goals of infection control.

Thus improving the quality of dental unit water is a natural way of maintaining high quality of patient care and staff protection.

Methods to reduce biofilm formation[2,3,6]

The following recommendations should help the dental professional in reducing the biofilm formation.

Antirretraction valves are fitted on modern hand pieces to reduce suck back from the oral cavity preventing a retrograde infection. Anti retraction valves can also be fitted on the waterlines.

Flushing the water lines for 2 minutes at the start of the day and for 20-30 seconds between patients. This will reduce the bacterial count by approximately 97% but will not reduce the total count to less than 200 cfu / ml nor will it remove the biofilm. So in most units flushing is insufficient on its own to control the bacterial count in the DUWL. In dental units that are not drained in the night, flushing at the start of the day will reduce the bacterial load caused by overnight water stagnation. Flushing between patients helps to prevent cross contamination by removing oral fluids introduced into the DUWL via suck back through the hand pieces.

Filters

Disposable microbial filters placed as close as possible to the hand piece will prevent suspended bacteria entering the hand piece but will not remove the biofilm. When installed near the hand pieces, filters offer a physical barrier to the passage of microorganisms. If used according to instructions, they perform well. Filters designed to purify water before it enters the dental unit can also be used. However, if the tubing is already colonized by biofilms, these filters will have only a minor influence on microbial output. However, usage of bacterial filtered water (Aqua guard unit) coupled with mechanical flushing of water lines for 2 minutes at the start of the day will bring down the bacterial count in due course Certain filters are impregnated with iodine, a strong antibacterial agent, which is gradually released into the water during the use of the hand pieces. This measure will reduce bacterial counts. However, some patients may have an allergic reaction to iodine which may also be life threatening.

Regular daily or weekly disinfection according to the manufacturer's instructions with products containing one of the following active agents: hydrogen peroxide, citric acid, iodine, chlorhexidine, 1:10 household bleach, ozone, electrochemically activated water will produce water of drinking standard. Not all products completely remove the biofilm, so regular dosing according to the manufacturer's instructions is required to control the bacterial count. The disinfectant can be introduced with a pressurized pump system or via an independent bottled water system. From a strictly microbiological point of view, most disinfectants reduce bacterial counts to an acceptable level, yielding the equivalent of potable water; however, they do not generate sterile water. Because some disinfectants are corrosive (e.g. bleach, which should never be used undiluted), the manufacturer of the dental unit should be consulted before any chemicals are introduced into the water system. In general, disinfectants are allowed to remain in the lines overnight, and are then flushed from the lines the next morning. If bleach is used, it should be left in the tubing for a short time only, and the system should then be rinsed with copious amounts of water and left to dry overnight.

Although the use of these products is not covered by any official recommendations, a dental practitioner may decide to adopt one of them judiciously bearing in mind that the water is to be used in the oral cavity as some of these products have not been independently tested, and their long-term effects on microbial communities are still unknown.

Independent bottled water systems. These systems are either an integral part of the dental chair or can be installed separately. They have the advantage of bypassing the mains system and avoiding contamination with Legionella and other waterborne respiratory pathogens. A growing number of dentists mistakenly believe that the use of distilled or sterile water in the dental unit minimizes the problem. It is important to remember that the tubing is probably already colonized by biofilms, so the distilled or sterile water will itself become contaminated as it passes through the lines. The use of distilled or sterile water is thus unjustified and probably useless, except in a self-contained system that is strictly maintained. Independent bottled water reservoir systems should be disinfected and then thoroughly rinsed with sterile water before refilling, to prevent build up of biofilm in the bottle. An example of a suitable disinfection regimen is diluted 1:10 in hypochlorite bleach solutions applied for ten minutes. At the end of the day disinfect the bottle,

which should then be stored dry and inverted. The dental unit waterlines should be drained dry. Examples of some sterile water delivery systems include a variety of oral surgical and implant handpieces systems, the Sterile Water Pump (Biotrol), the AXCS sterile Irrigation System (DentalEZ), AquaSept device (Lares Dental), SteriWater system (Veltek Associates).[7]

Water Testing

Pretesting dental unit water is virtually useless, as it is unlikely that water from any untreated dental unit will be free of microorganisms. However, after initiation of a treatment program, testing can be used to determine whether water quality is acceptable and whether the solution that has been adopted is worthwhile.

CONCLUSION

The chances of a patient experiencing an infection that can be linked to water used during a dental treatment are hard to estimate. The infective dose required to achieve infection in 50% of individuals exposed to a dental unit waterline pathogen can be as high as 1 x 10^{10} cells. The number of cells required to achieve an infective dose is unlikely to occur often, and the risk of infection is therefore exceedingly small. Nevertheless, the goal of infection control is to minimize risk from exposure to potential pathogens and to create a safe working environment in which to treat patients, especially in an era where public awareness of microbial threats is much greater than in previous decades, thanks to better education and public television documentaries.

In its efforts to control infection, the dental profession spends a lot of money on the purchase of gloves, masks, disinfectants, disposable devices and sterilizers and on the replacement of dental hand pieces damaged by repeated sterilization. The contamination of dental unit waterlines is an issue that now concerns the dental profession on a number of levels, since patients and staff are regularly exposed to water and aerosols generated from the dental unit. Improving the quality of dental unit water will have benefits not only in the present but also in the future. Although, most immunocompetent patients treated in the typical dental office are not at risk, the infective dose needed to establish infection in immunosuppressed, elderly and chronically ill patients is generally lower than for healthy children and adults. Therefore, if any solution to this problem which is satisfactory for all patients, regardless of their health status, is to be found then this issue of infection control must be addressed.

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