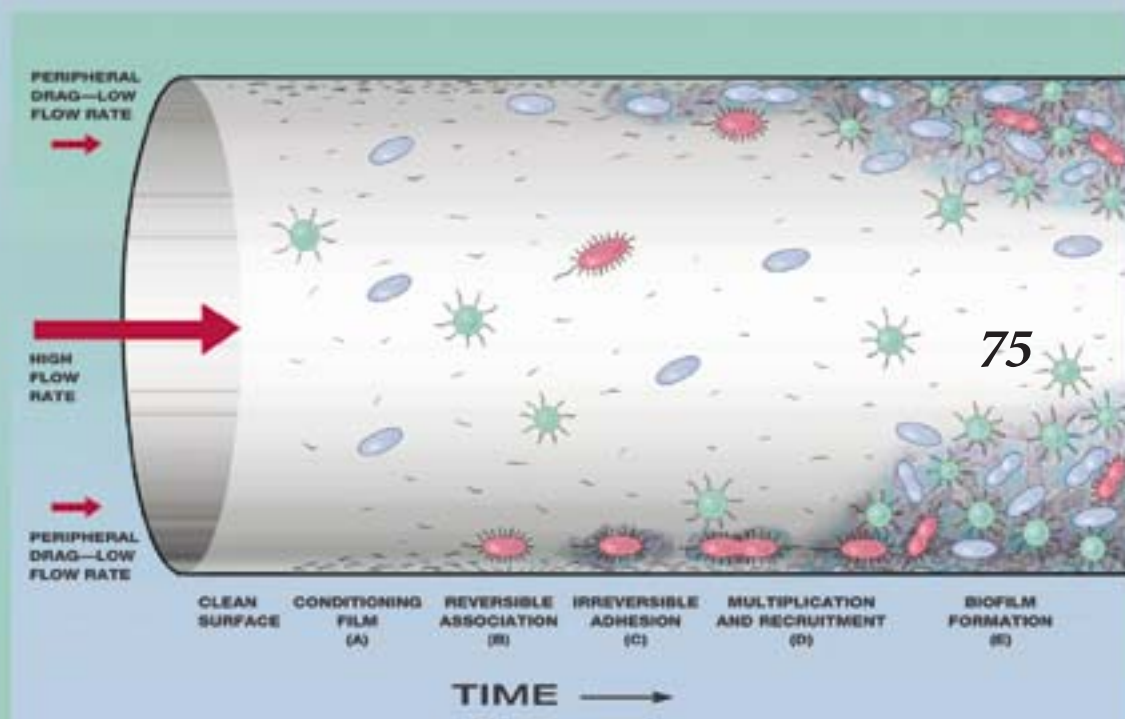


Dental Unit Waterlines: Potential for Contamination and Recommendations for Maintenance

by Brenda Denluck,* RDH

Figure 1. Biofilm formation in narrow-bore tubing. On adsorption of macromolecules from the aqueous phase and the formation of a conditioning film (A), bacteria may either associate reversibly with the surface (B) or adhere irreversibly (C). Subsequent division of adherent cells (D) and recruitment of planktonic cells from the bulk fluid phase results in biofilm formation (E). (Reproduced from Shearer.)



The public's awareness of microbial contamination has increased over the years, due in part to education and coverage in the popular media. Barbeau explained that the public's fear of microscopic germs has been engendered by companies that have been steadily introducing antimicrobial compounds into various aspects of daily living, including antimicrobial toys, clothing, laundry detergents, and hand soaps.¹ Outbreaks of waterborne infections have also brought about widespread concern regarding the quality of municipal water, and Pankhurst and Johnson commented that the notable increase in sales of bottled water is evidence of the public's concern.²

Along with the public's unease about municipal water quality, there has been an increasing interest and concern about the biofilms that are known to occur in dental unit waterlines, as demonstrated by the numerous studies and reports that have been published in recent years.

The purpose of this paper is to review the literature on microbial contamination of dental unit waterlines, to consider methods of infection control to minimize the exposure, and to identify the obligations of dental hygienists to their clients, as set out in the Standards of Practice and the Code of Ethics published by the College of Dental Hygienists of Ontario and the College of Dental Hygienists of British Columbia.

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Source: ADA Council on Scientific Affairs. Dental unit waterlines: approaching the year 2000. *J Am Dent Assoc.* 1999;130:1653–63. Copyright ©1996 American Dental Association. All rights reserved. Reprinted with permission.

WATERLINES AND CONTAMINATION

Water is deemed to be potable in Canada when there are fewer than 500 colony-forming units per mL (CFU/mL).¹ Dental unit waterlines have registered counts as high as 200,000 CFU/mL;¹ counts higher than 500 units/mL have been attributed to the development of biofilm in the waterlines. Biofilm is a matrix of microorganisms adhering to the surface of the waterline tubing. Pankhurst and Johnson explain that this adhesion occurs because of the physics of laminar flow. They note that water passes at its maximum flow rate through the centre of the tubing but at its minimal flow rate along the periphery of the tubing. This allows microorganisms to be deposited.² The design of dental units with narrow tubing results in a high ratio of tubing surface to water volume. This, combined with intermittent use patterns, leads to water stagnation and provides the ideal conditions for bacterial proliferation (see Figure 1). Even when new tubing is connected to a water supply, a biofilm will form within eight hours and reach its microbial matrix climax in six days.²

Exposure to contaminated dental water is a concern not only for clients but for dental personnel as well. Exposure can occur by "hematogenous spread during surgical procedures,

local mucosal...contact, ingestion and inhalation.”¹ It should be noted that “exposure does not always lead to transmission”³ and that humans are continuously exposed to microbial flora in “air, soil, water and food.” Another factor to consider is that just because there is a possible danger, it does not necessarily mean that there is an unacceptable risk.³ It is suggested, however, that there is a potential degree of risk for those “immunocompromised or immunosuppressed due to drug therapy, alcohol abuse or systemic disease” because they are susceptible to infections in general.² There is a minimal risk for healthy clients.³ When evaluating research and recommendation reports, consideration needs to be given to the fact that the risk of infection is derived from the virulence and the dose of the microbe and the host’s resistance.

Dental unit waterlines host many organisms, some of which are pathogenic. The two pathogens *Legionella* and *Mycobacterium* spp. that cause wound infections have been found in heavy concentrations, along with numerous other bacteria, fungi, and protozoa.² There are, however, few reported infections that have been linked to dental unit waterlines.¹ Two cases were reported in 1987 in the *British Dental Journal*, stating that “two...medically compromised patients had been infected with *P[seudomonas] aeruginosa* originating from dental unit water supplies.”¹ Other cases of infection and the development of oral abscesses in “two patients with solid tumours” have also been confirmed from exposure to *Pseudomonas aeruginosa* in the dental office.² Pankhurst and Johnson note that 68% of dental unit waterline samples had detectable *Legionella* spp. and that 8% had *Legionella pneumophila*. They also note that “comparable prevalence rates were observed in potable water samples.” However, the CFU/mL levels were significantly different with 19% of the dental unit waterline samples over 10,000 CFU/mL but none of the potable samples.²

In 1994, a dentist died with the suspected cause being inhalation of pneumonic legionellosis, likely from water sprayed from a handpiece. This, however, this was not demonstrated conclusively. There have also been reports of an eye infection from *Acanthamoeba* spp. resulting from splatter, a brain abscess, and gastrointestinal disorders.¹

Dental personnel are continually exposed to aerosols. There is a potential for disease transmission when solid or liquid airborne particles are expelled from the oral cavity. When these expelled droplets evaporate, “the residual droplet nuclei form and remain airborne in the operatory...subject to inhalation.”⁴ Evidence of “altered nasal flora” suggests that waterborne microorganisms are being inhaled from these aerosols.⁵ One study revealed that the “prevalence of antibodies to *L. pneumophila*...among dental personnel” was 34% compared with 5% for a “control population.”¹ However, there have not been any reported cases of *Legionella* pneumonia. A study from 1974 stated that the nasal flora of a number of dentists had an increased prevalence of waterborne *Pseudomonas* that was likely inhaled from contaminated water from high-speed handpieces.⁵ It has been suggested that a “lack of documented disease [*Legionella* pneumonia] among...dental care personnel” may indicate that there is insufficient exposure, adequate host resistance, subclinical infections, or a failure to link diseases to dental unit water.⁵

To further calculate the degree of risk involved, one must consider the problems of measurement. As already mentioned, everyone is exposed to microbial flora in a variety of ways, thus making it difficult to isolate effects actually caused by dental unit waterlines. Also, it must be taken into consideration that the sole measurement of CFU/mL is not a meaningful indicator in scientific calculations because if the temperature of the water changes by only one degree, the number of CFU/mL will change significantly.³

Although there is no evidence of a widespread public health problem and inadequate scientific evidence demonstrating serious health effects related to exposure from dental unit waterlines, the “goal of infection control is to minimise the risk from exposure to potential pathogens.”²

The American Dental Association’s Statement on Dental Unit Waterlines states that the currently available dental unit water systems are incapable of “delivering water of an optimal microbiologic quality.”⁶ The ADA’s Council on Scientific Affairs recommended a target of fewer than 200 CFU/mL. The Council suggests using a combination of methods to achieve this recommendation.⁶

WATERLINE MAINTENANCE

The Canadian Dental Association Board of Governors approved guidelines on dental unit waterline maintenance in 1997, which can be readily implemented by dental personnel.¹ The main recommendation for waterline maintenance is flushing for 5–8 minutes at the beginning of the day. Wilkins has also suggested that flushing should be done for “at least 5 to 6 minutes at the beginning of each day” and for 30 seconds between clients.⁷ Interestingly, in the United States where water is deemed potable when there are fewer than 200 CFU/mL, “the effectiveness of flushing has been challenged” since “the layer in immediate contact with the biofilm” remains stationary “during flushing.”² A recent study evaluated time-dependent waterline flushing and concluded that there is a statistically significant reduction in the number of CFU/mL after 2-, 3-, and 4-minute flushing compared with baseline samples and between each time interval. However, after four minutes of continuous flushing, the level of CFU/mL still exceeded the ADA recommendation and upon examination of the tubing by scanning electron microscopy, a residual biofilm remained.⁸ Another study reported that “flushing for 20 minutes... reduce(d) the bacterial count to zero;” however, within 30 minutes, the bacteria count returned to the “pre-flush range.”² The Organization for Safety and Asepsis Procedures (OSAP) “cautions that flushing” alone should only be used “as an interim measure until more effective methods” can be implemented.⁹

There are other possible approaches to reduce the risk of contamination. These include anti-retraction valves, filtration, independent water systems, autoclavable systems, chemical disinfectants, and water testing.^{1,2} Each approach has both advantages and disadvantages that will be discussed separately.

Anti-retraction valves limit the “re-aspiration of fluid from the oral cavity that occurs when negative pressure is generated on stopping equipment” and are most effective “when fitted immediately distal to the handpiece.”² However, they

can become clogged “due to biofilm deposition ...[and] require regular maintenance and programmed replacement.”² The potential for microbial cross-contamination led to the creation of the American National Standard Institute–American Dental Association Specification No. 47 in 1984, which specified that “water should not retract more than 2.032 cm back into the handpiece,” setting a standard for anti-retraction valve placement.⁴ To avoid reverse flow from suction tips, the College of Hygienists of British Columbia recommends that clients not close their lips and form a seal around the tip unless the tube is safety designed to this problem.¹⁰

Filtration systems remove bacteria from treatment water by means of 0.2-micrometer membrane filters. A variety of filter types are available and are most effective when fitted immediately distal to the handpiece. “Some filters offer a built-in antiretraction valve, iodine-eluting resin to inhibit downstream biofilm formation and filter materials designed to remove bacterial endotoxin.”⁵ The frequency for replacing filters varies depending on the type of filter used.⁵ One study “demonstrated that high levels of recontamination of DUW occur within 24 hours” due to “trapping and growth of bacteria on the filters. Therefore disposable filters are recommended” and they should be changed daily.⁴ It is recommended that filters be used in conjunction with another method to control biofilm formation.⁵ Another study evaluated the effectiveness of several disinfectants in combination with filters and concluded that “gluteraldehyde T4 was able to reduce the bacterial contamination” to less than 200 CFU/mL after a two-week maintenance program with the disinfectant being injected by a pump. However, to maintain water quality with the use of gluteraldehyde T4, “periodic biofilm removal” was necessary.¹¹ As well, Pankhurst and Johnson advise caution when using gluteraldehyde because of the “sensitisation of the human lung and skin.”²

Independent water systems bypass the main connection to the municipal water, utilizing reservoir bottles that provide pressurized sterile or boiled water. These systems require routine disinfection followed by flushing with sterile water, flushing between clients, and draining and “purging with air or ethanol...to prevent biofilm proliferation due to desiccation.”² Other independent water systems using distilled water require daily treatment with an antimicrobial agent such as Listerine Antiseptic, Bio 2000, Rembrandt, Dentosept, or 0.5% sodium fluoride to reduce microbial contamination to the acceptable level. However, the biofilm is not completely eliminated by this means and other methods would have to be employed.¹² A recent product review by Panagakos et al. indicates that Zerosil is an extremely effective, economical, and easy to use cleaning product for the elimination of viable organisms and biofilms in any reservoir bottle delivery system. However, it is still recommended to flush waterlines for “two to three minutes at the beginning of each day and for 20 to 30 seconds between each patient” along with the use of anti-retraction valves.¹³ The use of a “1:50 concentration of LA [Listerine Antiseptic] and sterile distilled water...with new tubing” was shown to be effective at maintaining microbial levels at less than 200 CFU/mL for prolonged periods. It was suggested, “since antimicrobial LA is safe for patient use, it may be one of the most viable options.”¹⁴

Fully autoclavable systems for dental units are independent water systems that deliver sterile water when properly maintained. They have “water reservoirs, ...dental unit waterline tubing and fittings to be sterilised between patients” to prevent biofilm formation.² Other systems have disposable tubing. These systems are effective when the instructions are strictly followed. However, they are “expensive to purchase and operate maintain and often are less convenient” to operate compared with other alternatives.⁵

Chemical disinfectants can reduce bacterial counts to an acceptable level, but they do not produce sterile water. Some common disinfectants used include sodium hypochlorite, ozone, hydrogen peroxide, chlorhexidine gluconate, ethanol, povidine iodine, Cavicide, gluteraldehyde, Listerine Antiseptic, Peridex, Sterilex Ultra, Sanosil and hydroperoxide ion phase catalyst (HPI-PTC). They can be introduced either intermittently, on a weekly basis, or continuously, on a daily basis, depending on the product.^{5,15–17} Of these products, the latter three hydrogen peroxide–based disinfectants seem to be the most popular in recent studies in the effort to control microbial levels and biofilm elimination.^{15–18} One must, however, closely evaluate the available products, as most just reduce the microbial count and only a few eliminate the biofilm. One study demonstrated that both Sterilex Ultra and bleach eliminated 90% of biofilm after one treatment, while Cavicide, Listerine Antiseptic, and Peridex resulted in “negligible elimination.”¹⁶ Another study between Sterilex Ultra and Sanosil showed that both reduced biofilm formation with weekly use; however, repeated usage of Sterilex Ultra was “associated with clogging of DUWs in some dental chair units after repeated usage.”¹⁵ A 5% solution of HPI-PTC successfully cleared biofilm after an initial three-day treatment and then maintained the recommended microbial levels with weekly use.¹⁷ Caution should be exercised with chemical products, however, as Barbeau notes: “the manufacturer of the dental unit should be consulted before any chemicals are introduced into the water system.”¹ The bacterial colonies in the biofilm will develop a resistance to biocides with extended exposure, therefore reducing their value.²

Water testing after the initiation of a treatment program can determine whether water quality is acceptable, whether the program is worthwhile, and can help identify problems. Barbeau comments that “pretesting dental unit water is virtually useless, as it is unlikely that water from any untreated dental unit will be free of microorganisms.”¹ “Routine testing for specific organisms such as *Pseudomonas* and *Legionella* is not recommended” and “should only be performed to investigate a suspected waterborne illness as directed by local health authorities.”⁹

Currently, there is “no...single method or device (that) will completely eliminate...dental unit waterline (contamination) or prevent the risk of cross infection.” It is therefore advisable to employ a combination of a disinfectant integrated with periodic biofilm removal for water quality maintenance.^{2,9} Also, organizations such as the College of Dental Hygienists of British Columbia recommend that clients not be provided drinking water from the air/water syringe.¹⁰ If choosing a chemical agent, one must ensure that the manufacturer supplies the Material Safety Data Sheet as well as any “other pertinent information...required by OSHA.” This is

to make certain that the chemicals are safe and that if some of the agent remains, it will leave “only safe levels of residues in the dental treatment water.” Furthermore, these residues should be compatible with dental restorative materials.”⁹

DENTAL HYGIENISTS’ PROFESSIONAL OBLIGATIONS

As set out in the Standards of Practice of the College of Dental Hygienists of Ontario,¹⁹ dental hygienists have many obligations to their clients related to the issue of dental unit waterline contamination. Dental hygienists have the responsibility to “maintain and apply current knowledge and skills” within their practice setting. In order to achieve this, hygienists must “gather, record and analyse the scientific data” available on dental unit waterline contamination and the proposed recommendations.¹⁹ To do this, hygienists must understand the concept of evidence-based decision-making and be able to effectively interpret the validity and reliability of report findings.

By completing a critical appraisal of the literature, hygienists are able to “choos[e] and us[e] any new product or technique that is supported by sound and scientific principles and that has demonstrated safety and effectiveness when used according to manufacturer’s directions,” thereby “ensuring the practice environment meets all legal requirements for workplace health and safety.”¹⁹

The Ontario Code of Ethics states that dental hygienists shall “commit to the highest level of professional efficacy through the maintenance and application of current, relevant knowledge and skill.” Therefore, dental hygienists must be knowledgeable regarding microbial contamination and biofilm formation in waterlines, and have an obligation to demonstrate this knowledge by incorporating the established results of scientifically sound methods that are recommended to prevent or control the microbial contamination of the waterlines within their practice.²⁰

The quality of water dispensed from dental unit waterlines is important since clients and dental personnel are routinely exposed to the water and aerosols that are generated from the dental unit. As the ADA Council on Scientific Affairs warns, the “dental profession must continue its awareness of the presence of high levels of opportunistic microorganisms in dental unit water. Despite the lack of evidence of adverse health effects related to these microorganisms, they have the potential to overload the defense systems of immunocompromised patients and occupationally exposed dental staff members.”⁵

CONCLUSION

Once one of the scientifically recognized methods or techniques for dental unit water maintenance has been chosen, it must be practised and monitored routinely to protect the health and safety of all clients. Equipment devices and solutions must have “clearly written precautions and instructions for installation, use, and maintenance” to improve “the probability of clinical success and reduce the potential” for equipment damage or personal injury.⁹

In this paper, various methods and techniques for waterline maintenance have been briefly discussed. Individual hygien-

ists have to determine which method or methods are the most reliable, economical, and suitable for their dental practice. By reviewing the literature, implementing and monitoring a method or technique, hygienists will be fulfilling their obligations to the profession and the public as set out by the Ontario Standards of Practice and the Code of Ethics published by the College of Dental Hygienists of Ontario and the College of Dental Hygienists of British Columbia.

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