Dental Water Asepsis: Rationale, Challenges, and Infection Control Strategies

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The demonstration of high concentrations of microbial accumulation in coolant water for high speed dental handpieces was first reported by Blake in 1963. This initial study served as the trigger for subsequent investigations into the mechanisms of colonization, potential health problems for dental health care providers and their patients, and possible approaches for resolution. As a result, numerous studies have shown that dental unit waterlines can be rapidly contaminated by organisms that thrive in aqueous environments, leading to the formation of biofilms inside the lumens of colonized water lines. Researchers have further identified multiple classes of organisms in collected water samples, ranging from nonpathogenic to pathogenic species. These include: Bacterionema spp.; Corynebacterium spp.; gram negative bacilli and cocci; Klebsiella spp.; Neisseria (N. catarrhalis); Pseudomonas spp., including P. aeruginosa, P. pyogenes, and Burkholderia cepacia; Staphylococcus epidermidis; Streptococcus mutans, Streptococcus salivarius, and Streptococcus mitis; Actinomyces spp.; Enterococcus spp.; α-hemolytic streptococci; Staphylococcus aureus; B. subtilis; E. coli; Flavobacterium; nonhemolytic streptococci; Legionella pneumophila; Mycobacterium spp.; Aspergillus niger; Cladosporium; Actinomycetes; and Alcaligenes faecalis.2-7

Although municipal water coming into the system from an external source is of potable quality (<500 colony forming units/milliliter [cfu/mL] of bacteria and <1 coliform), water coming out of dental units used in clinical facilities may be colonized with microbial concentrations ranging from 1,000 to 10,000 cfu/mL. Some units have even shown to harbor 1 million cfu/mL. This contamination occurs because a number of dental unit water line factors (e.g., narrow hollow bore design of plastic tubing, flow rates, materials) promote bacterial growth and development of biofilm over time.

Previously, there wasn’t any documented evidence of individual cases or outbreaks or serious health problems for either patients or dental health care professionals (DHCP) resulting from contact with dental water. Recently, however, investigators reported in the medical journal The Lancet the first case of a fatal patient infection from exposure to bacteria in dental waterlines. The patient was an elderly woman who succumbed to fulminant Legionnaires’ disease in February 2011. The source of the Legionella pneumophila infection was ultimately traced to the high speed handpiece waterline in the dental practice where she had been treated during 2 appointments.

This unfortunate case serves to reinforce the importance of ongoing efforts to implement and utilize effective infection control precautions during provision of patient care. In addition, when one considers universally accepted infection control principles and the high level of asepsis routinely exhibited in most dental facilities, exposing patients or DHCP to water of poor microbiological quality is inconsistent with current infection prevention practices. As a result, health professional associations and governmental agencies continue to respond to concerns by developing guidelines and, in some instances regulations, to address this issue. The following sections will attempt to discuss the area of dental water asepsis by using a question/answer format to review, among others, health implications of microbial colonization, governmental recommendations and regulations for health care facilities, and evolution of infection control strategies.

Fig. 1: Corynebacterium
Fig. 2: Klebsiella
Fig. 3: Neisseria
Fig. 4: Pseudomonas
Fig. 5: Streptococcus mutans
Have there been reported incidents of cross-infection associated with contaminated water in healthcare facilities?
Prior to the recent Legionnaires’ disease report occurring in a dental patient, there have been published clinical investigations documenting waterborne infections and disease in hospital settings.8-10 Waterborne pathogens, especially Pseudomonas, non-tuberculous Mycobacterium species, and Legionella species were the most commonly cited etiologic agents. Medical devices associated with these infections include nebulizers, endoscopes, otologic equipment, and hemodialysis units.

With specific regard to dental facilities, the overwhelming majority of microbes isolated from dental waterlines originate from the local municipal water supply. These microbes do not typically pose a high risk of disease for healthy persons. However, Pseudomonas, Klebsiella, Legionella, and non-tuberculous Mycobacterium species and other potential pathogens have been isolated from dental water supplies. In addition, two published reports in the 1980’s suggested increased exposure of dental health care workers to legionellae from aerosolized dental water.11-12 As more people with weakened immune systems seek dental treatment, more questions arise about the potential role waterborne organisms could play as “opportunistic pathogens” in a similar manner as described with hospital outbreaks.13

What are biofilms and how do they populate dental unit waterlines?
Microbial biofilms are found virtually anywhere that moisture and a suitable solid surface for bacterial attachment exist. Biofilms consist primarily of naturally occurring slime-producing bacteria and fungi that form microbial “communities.” This bacterial film tightly adheres and lies flat against the walls of the small-bore plastic tubing in dental units that deliver coolant water to high-speed handpieces and air/water syringes. As water flows through the microbial matrix, microorganisms may occasionally be released into the effluent water.

Biofilms are characterized by cells that are: 1. irreversibly attached to a substratum or interface with each other; 2. embedded in a matrix of extracellular polymeric substances that they have produced; and 3. grow as a distinct community of bacteria and other microorganisms acting as a self-perpetuating and self-protecting unit. As mentioned above, they can harbor numerous waterborne bacteria, fungi, protozoa, even nematodes. While at first glance biofilms may appear as merely amorphous masses on water-laden surfaces, they have a surprisingly complex structure.13

Of particular importance to both possible infectious exposure and the public’s perception of microbial exposure, some clumps of biofilm may be dislodged and come out as solid material as water flows through the lines.

What is the evolution of statements by professional organizations and governmental agencies regarding addressing dental waterline challenges?
In response to growing concerns about the quality of dental water used in patient treatment the American Dental Association convened an expert panel in 1995 to discuss and address the issue. A subsequent statement was published establishing goals for improving dental unit water. This statement also encouraged the industry and researchers to provide dental equipment with the ability to deliver treatment water with 200 colony forming units (cfu)/mL or less of

Fig. 6: Enterococcus
Fig. 7: E. coli
Fig. 8: Legionella pneumophila
Fig. 9: Mycobacterium
Fig. 10: Aspergillus niger
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unfiltered output from water lines. In 2003, the U.S. Centers for Disease control and Prevention (CDC) published comprehensive updated infection control guidelines. These recommendations include a limit of no more than 500 cfu of heterotrophic bacteria per mL in dental water, the flushing of dental waterlines at the beginning of the day and between patients, and the use of sterile water or saline for irrigation of surgical sites where bone is exposed. The CDC recommends the same level of standard that exists for safe drinking water.

The Canadian Dental Association (CDA) Committee on Clinical & Scientific Affairs published similar guidelines in 2006. In part, their recommendations stated: “The potential risk of infection from dental unit waterlines (DUW) microorganisms can be effectively reduced to counts to potable water standards (i.e. less than 500 cfu/mL) following regular waterline maintenance procedures”. These were subsequently expanded in the development of the most recent Alberta Dental Association and College (ADA) provincial standards and Royal College of Dental Surgeons of Ontario (RCDSO) recommendations, respectively. Both documents contain essentially the same procedures for waterline maintenance. Statements from the ADA Infection Prevention and Control Standards published in 2010 are provided below:

- The dental clinic must use a water supply, which is tested for, and is free of contaminants, such as from a monitored municipal water supply; unless there is a boil water advisory. Non-monitored water supplies should be tested biannually.
- Waterline heaters should not be used in a dental unit or in dental equipment, as these heaters encourage waterline microorganism growth.
- All waterlines must be purged at the beginning of each workday by flushing the lines thoroughly with water for at least two minutes. This purging should not be done with handpieces, air/water syringe tips and ultrasonic tips attached to the waterlines.
- Handpieces utilizing water coolant must be run for at least twenty seconds after patient care, in order to purge all potentially contaminated air and water. A sterilized handpiece can then be attached, following regular clinical contact surface management.
- Sterile water or saline must be used when irrigating open vascular sites and whenever bone is cut during invasive surgical procedures. Conventional dental units do not reliably deliver sterile solutions, even when equipped with independent water reservoirs or microfilters, due to the formation of biofilm along the water pathway. Delivery systems, such as a bulb syringe, should be used to deliver sterile irrigation solutions.
- When closed water systems are used, DHCP should be careful not to touch the tubing with the fingers or gloved hand when changing the water coolant, as this easily contaminates the entire system.
- Manufacturers’ instructions of the dental units and dental equipment must be followed for daily and weekly maintenance whenever closed water systems or other special water delivery systems are utilized.

What kinds of commercial products are available to assist clinicians in their efforts to improve the quality of dental water?

A common approach used by practices for many years involved flushing water through waterlines for variable intervals. While this procedure is able to remove free-flowing (i.e. planktonic) organisms suspended in waterline fluids, the beneficial effects of mechanical flushing have been shown to be transient. Recommendations from the CDC, ADA, and the RCDSO do include flushing waterlines between patients to eliminate any patient material that may have been retracted into handpieces and air water syringes during dental procedures, however, they do not consider this procedure to be an effective means for reliably improving dental water quality.

A range of engineering and work-practice controls have been evaluated for this purpose. As a result, a variety of commercial products are currently available to the profession to control microbial contamination in dental waterlines. These choices are as follows:

1. An alternate water supply that bypasses community water and dental water systems by providing sterile or distilled water directly into water line attachments (i.e. separate reservoir) combined with chemical treatment.
2. Filtration involving in line filters to remove bacteria immediately before dental unit water enters instrument attachment.
3. Chemical germicides or cleaners that inactivate or remove microbial contamination (sometimes described as intermittent “shock” treatment).
4. Chemical germicides or cleaners that prevent microbial contamination in new or cleaned systems (sometimes referred to as “continuous” treatment). These products may be added to or used as the irrigating solution for clinical use.
5. Thermal inactivation of facility water at a centralized source.
6. Reverse osmosis or ozonation using units designed for either single chair or entire practice water lines.
7. Ultraviolet irradiation of water before entrance into individual unit water lines.
Desirable Properties for DUWL Treatment Strategies

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<th>Property</th>
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<tr>
<td>Non-toxic to equipment or patients</td>
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<tr>
<td>Non-pyrogenic</td>
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<tr>
<td>Non-allergic</td>
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<td>Non-corrosive to metals</td>
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<td>No damaging effects on rubber or synthetic materials</td>
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<td>Does not interfere with performance of restorative or therapeutic agents</td>
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<td>Rapid “cidal” (i.e. lethal) antimicrobial action</td>
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<td>Broad-spectrum anti-microbial activity</td>
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<td>Ability to disrupt/disperse accumulated biofilms</td>
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<td>Environmentally friendly or “green”</td>
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Table 1

A number of features should be considered when dentists and staff evaluate any of these types of products for possible use in their practice. These are summarized in Table 1.

Products claiming many of the attributes listed in Table 1 are now being marketed. Before introducing any chemical agent into a dental water system, the user must seek assurance from the manufacturer that the product is non-toxic, will not damage the dental unit and—if continuously present in treatment water, that it will not harm the patient or dental healthcare professional or interfere with restorative bonding agents.

The keys for accomplishing DUWL asepsis remain the same as for other infection control goals. Contaminated waterlines, like contaminated hands, instruments, and environmental surfaces, should first be cleaned to remove accumulated microbial and extracellular material. This should be done prior to working to maintain low microbial levels. Compliance with a manufacturer’s step-by-step procedures for accomplishing initial removal of accumulated material is essential. Minimizing subsequent DUWL colonization may require another series of protocols, some of which may be more time consuming than anticipated. Thus, the entire dental team should be aware of the necessity for compliance, and the time required to attain the recommended DUWL microbial concentrations.

Research developments in recent years have led to both greater individual product options for dental practitioners, but also the availability of combination systems which contain separate waterline cleaning agents and maintenance chemicals. This approach minimizes the necessity and possible confusion that can arise from evaluating, purchasing and using multiple types of products from different manufacturers. Remember to ask the appropriate questions when discussing available product choices with manufacturers’ representatives, and then be certain to evaluate what approach will work best in your specific facility.

References