A Review of Treatment Methods of Dental Unit Waterlines

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ABSTRACT

Dental unit waterlines (DUWLs) are the tubes that connect the high-speed handpiece, three ways syringe and ultrasonic scaler to the water supply. The source of water is either from public water supply or independent water reservoir. The contamination of water from DUWLs with micro-organisms was first reported nearly 50 years ago. This issue has resurfaced lately because of an increased awareness of potential occupational hazards and concern about the increasing numbers of immunocompromised patients seeking dental care. Possible ways of transmission of infection from contaminated DUWLs is by aerosol droplet inhalation or open wound contamination in susceptible individuals. Modern methods aiming to reduce DUWLs contamination include: anti-retraction valves and retrograde aspiration of oral fluid, filtration, flushing, using biocides and chemical disinfectants, chlorination, peroxide, ozone and ultraviolet light, independent clean water system, autoclavable systems, electrochemically activated water and drying. Literature review shows that water quality of DUWLs is improved irrespective of the method used but contamination recurs within short period of time if there is no proper maintenance. Search through literature reveals no documented health effects associated with exposure to DUWLs. However, transmission from contaminated DUWLs has been occurred and scientific evidence supports the needs to improve the water quality of DUWLs for better patient care. This paper reviews the biofilm of DUWLs, the available water treatment measures and the recommendations for dental professionals to improve and maintain the quality DUWLs for better patient care and a safer working environment for dental health care personnel.

Keywords: dental unit water lines, biofilm, water treatment measures

INTRODUCTION

The issue of biofilm and bacterial contamination of DUWLs first appeared in the literature nearly 55 years ago [1]. DUWLs are the small-bore flexible plastic tubings that connect the high-speed handpiece, three ways syringe and ultrasonic scaler to the water supply (**Figure 1**). The function of DUWLs is to bring water to these equipments for cooling. The source of water is either from public water supply or independent water reservoir (**Figure 2**). The quality of water from DUWLs is important especially to dental staffs as they are regularly exposed to the water and aerosols generated. It can serve as a potential source of indirect infection to dental health care personnel. Medical risk of DUWLs contamination is most significant for immunocompromised individuals.

Extensive tests and research done in America showed that traditional dental clinic using public water supply has an average of 375,000 colony forming units of bacteria per milliliter (cfu/ml) of water sample. Those with independent water reservoir averaged 1,200,000 cfu/ml. Microbial loads as high as 1.6 x 108 cfu/ml has been reported in unmonitored DUWLs [2,3,4]. In unmaintained DUWLs systems, these microbial accumulations can contribute to objectionable odour when the dental unit is in function 5.

Various microorganism including bacteria, fungi and protozoans have been shown to colonize and replicate in DUWLs resulting in the formation of biofilms. Study of Barbeau et al [6] showed more than 10% of the water samples from DUWLs had Pseudomonas aeruginosa, whereas study by Sculze-Robbecke [7] showed that 50% of the DUWLs samples had Mycobacterium species. Occupational exposure of dental health care personnel to Legionella species had been reported [8].

A search through literatures revealed no documented health effects associated with exposure to DUWLs. However, transmission from dental lines has been reported [9] and scientific literature supports the needs to improve the quality of DUWLs for better patient care.

The objective of this paper is to review the biofilm of DUWLs, the currently available water treatment methods and the recommendations for dental professionals to improve the water quality of DUWLs.

RECOMMENDED STANDARD OF WATER QUALITY FROM DUWL

In 1995, American Dental Association recommended that water delivered to patients during non-surgical dental procedures should contains no more than 200 cfu/ml, whereas Center for Disease Control 10 (CDC) in 2003 recommended that drinking water should contains no more than 500 cfu/ml and the standard of water form DUWLs should be equal to this. Although there is no evidence that water from DUWLs affects patients' health status, CDC [10] states that "Exposing patients or dental health care personnel to water of uncertain microbiological quality, despite the lack of documented adverse health effects, is inconsistent with generally accepted infection control principles [11].

BIOFILMS

Aquatic biofilms, which are well-organized communities of microorganisms (bacteria, fungi and protozoa) are widespread in nature, including community drinking water systems.

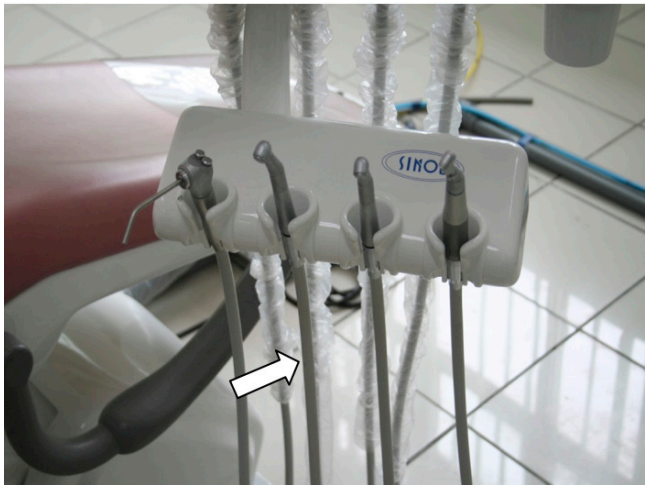

Figure 1. Dental unit waterlines of different models of dental units (white arrow)

Figure 2. Independent water reservoir

Opportunistic pathogens are known to colonize the synthetic surfaces of DUWLs and without proper maintenance, can increase its concentration to potentially dangerous levels 6 as the insoluble exopolysaccharides of biofilm shield the microorganisms from penetration and displacement by predator organisms, antibiotics and disinfectants.

Detachment of microorganisms from dental unit biofilm could theoretically infect the patient by flushing into the oral cavity. Splatter and aerosols from dental procedure may possibly infect health care personnel [10]. Water entering DUWLs is often of good microbiological quality, but becomes contaminated after shedding of microorganisms from the biofilm in the waterlines [6].

The groups of population that are most susceptible to waterborne pathogens are immunocompromised patients, namely patients with cystic fibrosis, AIDS, elderly and chronically ill patients. Dental health care personnel that are regularly exposed to pathogen-loaded aerosols are also at risk [10]. Transmission from DUWLs has been reported by Martin [9] in 1987.

Two patients developed serious Pseudomonas infections after dental treatment. The waterlines were tested and revealed the identical bacterial strain. All the other patients were tested for Pseudomonas infection retrospectively and all the patients tested had a positive titer. Fortunately, the patients were all healthy individuals. Results might have been very different if they were immunocompromised.

Newly installed DUWLs reached a peak level of water contamination within five days with microbial count upto 200,000 cfu/ml 6. The less a waterline is used, the more likely it is to be contaminated with Pseudomonas aeruginosa, which is the most common pathogenic bacteria identified in DUWLs [6].

DUWLs are extensively colonized because their bore tubes are narrow and not routinely disinfected. Various factors, including ambient temperature, source of water, length and type of tubing, low flow rate, low used volume and stagnation contribute to the formation of biofilm. Two main possible sources of microorganism that present in the biofilm of DUWLs are: municipal water piped into the dental unit and suck-backed of patients' saliva into the line due to lack of anti-retraction valves.

Many findings confirmed that a substantial proportion of DUWLs have high levels of microbial contamination, irrespective of country, type of dental chair and source of water. Various studies also showed that in 63 % of cases, the number of cfu/ml and of coliform organisms in water reservoir of dental units significantly exceeded acceptable values [12].

Majorities of microorganisms isolated form DUWLs are of low pathogenicity. However, the public health significance of these pathogens is still unclear. Studies done emphasized the need for effective mechanisms to reduce the microbial burden within DUWLs, and highlight the risk of occupational exposure and cross infection in general dental practice [13].

Most of the bacteria isolated from DUWLs are gram negative bacteria which are able to produce endotoxin. The organisms of real concern are Pseudomonas and Legionella. Pseudomonas is a natural water-loving biofilm producer, that when aerosolized can cause pneumonia-like disease in elderly or immunocompromized individuals. Legionella has been found in waterlines where dentist has become seriously ill in a case from San Francisco [14].

DENTAL UNIT WATERLINES TREATMENT MEASURES

The ultimate goal for infection control in DUWLs is to minimize the risk from exposure to potential pathogens and create a safe working environment for treating patients. Modern methods aiming to reduce DUWLs contamination concentrate on two aspects, which are treatment of dental water and improvement of dental unit design. These include: (1) filtration, (2) flushing, (3) antiretraction valves and retrograde aspiration of oral fluid, (4) using biocides and chemical disinfectants, (5) chlorination, (6) peroxide, ozone and ultraviolet light, (7) independent water reservoir, (8) autoclavable systems, (9) electrochemically activated water and (10) drying.

Filters have to be installed near the point of use for it to be effective, that is between the waterline and the dental instrument. It is suitable for dental units with municipal water supply. However, it was established that using filters on the DUWLs has no impact on biofilm formation [12] but it can prevent microorganism reaching the handpiece provided the filter pores is smaller than the size of pathogenic microorganism. The disadvantage of filters is prone to clogging with bacteria and hence has to be changed frequently. Filter reduces or eliminates the dependence on chemical agents and indirectly reduces the risk of staff exposure to chemical agents and less risk of damage to dental equipments [15].

Draining waterlines for several minutes before treatment reduces bacterial counts significantly [6]. However, flushing removes only the accumulated planktonic form and a few of the biofilm surface-absorbed microorganisms. It is recognized that flushing provides only temporary reductions in bacterial load and has no effect on the biofilm formation. It is insufficient to reduce bacterial counts below the recommended levels of drinking water unless unrealistically long clinical time is used [3]. Flushing must be carried out in such a way as to avoid misting which can cause contamination of the ambient air [16]. This is the easiest and most economy way to reduce contamination of water from DUWLs. ADA (1999) 5 recommends all dentists to consider this way of controlling the microbiological quality of water from DUWLs until more effective method is introduced.

Various studies have been done to evaluate the products that claimed to reduce the microbial loading of DUWLs and to remove the biofilm that attached to the inner surfaces of the DUWLs.

Karpay et al studied the efficacy of combined intermittent and continuous treatment with diluted sodium hypochlorite (NaClO) in a clinical setting [4]. They revealed that NaClO was able to reduce the microbial to the level recommended by ADA 5. Biofilms is 3,000 fold less susceptible to hypochlorite and therefore are not readily degraded even by concentrated solutions of bleach or other disinfectants such as glutaraldehyde. Planktonic organisms will be destroyed, but even if majority of the organisms in the biofilm are eliminated, the architecture of the biofilm survives and acts as a pre-formed matrix for renewal of the biofilm. Inactivation of biocides is further impaired by interaction with organic material and electro-repulsion caused by surface charges on the biofilm [17].

A between-patient disinfection procedure consisting of flushing DUWLs with peracetic acid was efficacious in the control of both microbial contamination of DUWLs and the biofilms [18].

Zanetti et al [19] demonstrated that treatment of DUWLs with hydrogen peroxide was able to keep the number of the bacteria under control, as long as the treatment was repeated daily. Larsen et al [20] evaluated the effect of a disinfectant agent based on hydrogen peroxide (Sterilex Ultra) on the microbiological quality of water in DUWLs. Instillation of Sterilex Ultra according to the recommendation of the manufacturer initially reduced the number of bacteria in DUWLs to <102 cfu/ml.

However, following daily and prolonged administration of Sterilex Ultra, a gradual recolonisation was observed in a number of dental units, with bacterial numbers more than 104 cfu/ml. Neither daily nor extended administration of Sterilex Ultra was capable of maintaining an acceptable water quality in these older dental units [20].

Porteous et al 6 tested the efficacy of a continuous use of stabilized chlorine dioxide product. Treated units showed a decline in the mean number of cfu/ml. However, it was found that the level was not consistently low enough to meet the recommended levels of ADA [5].

Intermittent treatment of DUWLs with 0.12% chlorhexidine gluconate (CHX), in a proprietary formulation, resulted in bacterial counts reduced to levels that were consistently below the ADA goal of 200 cfu/ml [5].

Meiller et al [21] evaluated ICX, Adec's water treatment solution in a series of experiments to assess the microbial spectrum activity, minimum inhibitory time determination and treatment of established biofilms. They concluded that ICX is effective in maintaining the effluent within the ADA and CDC's recommendation. In addition, since the preliminary findings show that ICX reduces microbial contamination of effluents from established biofilm lines, it may be useful in long term treatment either alone or in coupled with a shock treatment to assist in biofilm destruction. However, this is subject to further evaluation with bigger scale of study.

Study by Kohno et al [22] indicates that temporary inflow of acidic electrolyzed water could be applied as a measure against bacterial contamination of the DUWLs.

Research of Walker et al [13] to monitor the water emitted from dental units without independent water reservoir shows that dental units attached to centralized combined water distillation-cleaning solution distribution systems can produce water with less than 200 cfu/ml and missing of one weekly cleaning did not negatively affect the water quality.

Furthermore, study by Walker et al [13] also indicates that independent water reservoir can reduce the numbers of micro-organisms released from DUWLs compared to central water source. Independent water reservoirs have the advantage of able to add in disinfectant. However, care must be taken to ensure that before the water bottle is used, it has been disinfected by a non-toxic solution. The water that is to be added to the bottle should be either sterile or distilled and there is proper maintenance. Otherwise, the water bottle itself would become another reservoir for microorganism.

Martin et al [23] showed that super-oxidised water can be used successfully in the removal of bacteria from the DUWLs. Complete removal required the treatment with a purge phase of concentrated disinfectant and a maintenance phase of at least two weeks. Practitioners are advised to consider the use of sterile water for non-surgical, as well as surgical treatment for immunocompromised patients [6].

However, the sterile solution has to be delivered via equipment other than DUWLs. These instruments might be expensive to purchase, difficult to maintain and inconvenient to use. Nonetheless, small volume of the solution can be delivered using a sterile disposable syringe.

The tubes of DUWLs can be modified so that it composed of materials that do not promote the formation of biofilm or it can kill the microbial when it is formed [24]. However, studies had yet to be done to demonstrate the effectiveness of such modified tubes over long term [25].

Anti-retraction valves can be used to prevent the aspiration of contaminated fluid and reduce the risk of transfer of potentially infective material [10]. Dental units have been demonstrated to retract saliva from patients under treatment and to release it into the mouths of subjects undergoing the next operation [18]. Study conducted by Montebugnoli and Dolci [18] showed that anti-suction devices could reduce but not prevent penetration into the air chamber of a high speed handpiece.

Programmed automatic treatment device has been inserted into dental treatment units to flush disinfecting solution automatically through the water/suction system between patient visits [26]. A slow released, chlorhexidine acetate based devise has been successfully keeping units free of bacteria over 3 months period. However, effective cleaning of the tubing was essential for successful maintenance [24].

Studies showed that ozone (O3) has a promising results when use for treatment of DUWLs [27]. The advantages of using ozone in treating DUWLs is it acts instantly on bacteria, fungi, viruses, prions and their effluent molecules. Hence, microorganisms cannot evolve fast enough to develop resistance. Ozone does not leave biocidal traces and as a result, the risk of contamination in bonding procedures is minimised. However, ozone has to be prepared at the time of use because it is a very unstable gas and special equipment is needed to deliver the gas. More studies are required to validate the minimum concentration of ozone required for it to be effective and the effectiveness of this treatment measure.

Drying DUWLs did not reduce the number of living bacteria in DUWLs; this procedure therefore has no effect on the biofilm [12].

A growing number of dentists mistakenly believe that the use of distilled or sterile water in the dental unit minimizes the contamination of water from DUWLs. 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 [12].

Pretesting dental unit water is of no use as it is unlikely that the 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 the solution adopted worthwhile.

Improving the quality of DUWLs would benefits the present and future patients. Minimal cfu/ml in DUWLs is desired but careful monitoring to determine treatment effectiveness is also required as it has been shown that continuous treatment of the waterline may have resulted in overgrowth with fungus [6].

CONCLUSION

Contamination of DUWLs is universal. It is difficult if not impossible to eradicate the biolfim in these tubing and prevent its regrowth. However, every attempt has to be taken to minimize the contamination of the tubing in order to maximize the health of the dental health care personnel specifically and patients generally. Although the number of published cases of infection resulting from exposure to water from contaminated DUWLs is limited, there is a medico-legal requirement to comply with potable water standards and to conform to public perceptions on water safety. Practitioners are advised to identify a product that compatible with the dental units (as recommended by the manufacturer) and develop a schedule for waterline maintenance. It is recommended that a staff is assigned for this duty and a protocol is developed to monitor the quality of DUWLs regularly to ensure standards compliance.

A well-designed water quality indicator should be self-contained, simple, inexpensive and easy to use in-office to estimate the number of free-floating heterotrophic bacteria in dental unit water. It is important that waterline treatment schedules include water quality monitoring system/device This water quality monitoring device should be able to accurately detect a wide concentration range and type of aerobic mesophilic heterotrophic waterborne bacteria within a reasonable incubation time at room temperature.

Practitioners are urged to understand the limitations of available DUWLs treatment methods. Devices must be used and maintained according to manufacturers' instructions. Failure to do so could result in higher levels of bacterial contamination in the water. The ideal product should deliver the quality of water desired for either surgical or non-surgical procedures. Products and disinfection techniques must be proven to be effective and safe [28] and non-corrosive to the dental equipments. Annual costs and maintenance fee should be taken into consideration too.

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