

CONTROL METHODS OF THE MICROBIAL WATER QUALITY IN DENTAL UNIT WATERLINES

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Abstract: Microbiological control of water quality in dental units waterlines is extremely significant for patients and dental personnel. Based on the latest scientific literature, ways of reducing microbial contamination of dental treatment water and biofilm elimination are presented. The use of disinfectants, drying, and flushing are described. Further research to evaluate effectiveness, convenience on a day-to-day basis and economic aspects of various methods is required.

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INTRODUCTION

A dental unit is furnished with a system of thin, plastic tubes, called dental unit waterline (DUW), delivering water to the different handpieces. The water cools high-speed handpiece, is necessary in air/water syringes and ultrasonic scalers. The water may circulate in an open system, where its source is a municipal water supply, or in a closed system, where it is taken from a container belonging to a unit. The quality of dental water is of considerable importance since patients and dental staff are regularly exposed to water and aerosols generated from the dental unit. Bioaerosols, as a source of indirect infection for dentists, may constitute occupational hazards in their work [20]. Medical risk of dental unit waterline contamination is most significant for immunocompromised individuals.

For years, numerous attempts have been made, using various methods and focusing especially on the microbial contamination of water, to guarantee an appropriate quality of water used in dental treatment. A possibility to reduce the bacterial contamination of water down to a lower limit suggested by the American Dental Association (ADA) - bacterial loads ≤ 200 cfu/ml (colony forming

units per millilitre) – is considered. The goal of infection control is to minimise the risk from exposure to potential pathogens and create a safe working environment to treat patients [17].

Direct sources of DUW bacterial contamination are: 1) municipal water piped into dental unit and 2) suck-back of patient's saliva into the line due to lack of preventive valves. An indirect source of contamination, forming within the waterlines, is a biofilm developing in small-bore plastic tubing. The biofilm consists of colonies of bacteria, fungi, protozoa adhering to the inner surfaces of DUWs. The initial biofilm layers grow through replication of organisms that make up the biofilm, as well as adherence of free-floating microorganisms from the water source. With time, individual microorganisms, as well pieces of the biofilm, can dislodge and pass out of waterlines [16]. DUWs are ideal environment for growth of microorganisms. According to Barbeau *et al.* [3] DUWs should be considered an aquatic ecosystem in which opportunistic pathogens successfully colonize synthetic surfaces, increasing the concentration of the pathogens in water to potentially dangerous levels. Microbiological contamination of DUWs is thought to be the result of biofilm formation.

BACTERIAL CONTAMINATION

Microbiological studies of dental unit water samples from 150 surgeries revealed widespread and unacceptably high levels of contamination. Biofilm formation along the wall of the fine-bore waterlines is primarily responsible [23]. A later study showed that none of the waterlines was spared from bacterial contamination, among 121 dental units located at the dental school of Université de Montréal. A significant difference was also observed between samples taken at the beginning of the day and samples taken after a 2-min purge. Differences were also found between water from the turbine and the air/water syringe. Random variation occurred mainly between measurements (80%), and to a lesser extent, between dental units (20%). Also, it was observed less than a week after their installation, the newly installed dental units at the dental school yielded bacterial counts above 2×10^5 cfu/ml [3]. Similarly, Monarca's *et al.* [15] research showed bacteriological contamination of the dental unit water in all the 20 dental offices.

Identification and characterization of the microflora in DUWs is presented in numerous studies [1, 2, 3, 13, 15, 17, 19, 20, 22, 25], and showed that most of these bacteria belonged to the *Pseudomonadaceae* family. Some of the microorganisms identified are known opportunistic pathogens.

The significance of the problem is demonstrated by the participation of many American institutions which asked a group of experts to critically review the scientific literature on the subject in an attempt to determine the evidence basis for management of DUWs contamination and potential health risks, if any, in dental procedures. The evaluation yielded 4 questions that need to be addressed in future research: What is the safest and most effective agent(s)/device(s) for achieving microbial levels of no more than 200 cfu/ml, in the effluent dental water? How should these products be evaluated and by whom? What are the adverse health effects, if any, of chronic exposure to dental bioaerosol or to the agents introduced into the dental unit to treat the waterlines for both dental staff members and patients? How could these health issues be evaluated? [5]

Recently, the Council of Scientific Affairs of the ADA published a list of products cleared by the FDA to control dental waterline contamination. Simultaneously, the awareness of the risks related to biofilm formation was increased and information on techniques and devices designed to control the microbial contamination of DUWs was provided [18].

CONTROL METHODS

Monarca *et al.* [14] evaluated the effectiveness of methods of chemical decontamination using different disinfectants (peracetic acid, hydrogen peroxide, silver salts, chloramine T, glutaraldehyde T4) and methods of physical decontamination using synthetic membranes for the filtration of water. A preliminary removal procedure of the biofilm present in the waterline has been applied in

the dental unit prepared for the research purpose. Subsequently, different 2-week long maintenance procedures were applied using disinfectants injected by a pump and finally the bacterial contamination of the water flowing from waterline was evaluated. The physical decontamination was performed using 0.22 μm membrane filters, which have been installed in another dental unit, and the filtered water was analysed to detect bacterial contamination. The preliminary procedure of biofilm removal succeeded in obtaining germ-free water. Among the disinfectants used for maintenance of the water quality only glutaraldehyde T4 was able to reduce the bacterial contamination under the limit suggested by the ADA. The membrane filter system was not efficient in purifying the water, but the use of a disinfectant (peracetic acid) in the last part of the waterline yielded good results. At present, no decontamination system of dental waterlines is available, and glutaraldehyde T4 seems to be the best disinfectant but only if integrated with periodic biofilm removal for the maintenance of the water quality.

Other studies assessed water samples from a hospital dental clinic to determine whether a disinfectant/coolant irrigant containing chlorhexidine (Lines, Micrylium Laboratories) affects the presence of microbial organisms in dental unit waterlines. It was shown that decontamination of dental unit waterlines is possible using disinfectant/irrigant followed by sterile water irrigation. The potential for contamination of the lines from patients' saliva may be reduced by the use of preventive valves and the disinfectant/sterile water irrigation, as shown in this study [6].

Irish researchers [22] investigated the efficacy of 2 hydrogen peroxide-based disinfectants (Sterilex Ultra and Sanosil) in reducing bacterial loads to safe levels. The chemical quality of dental chair unit input and output water was well within the limits recommended for potable water. Water supplied to the units yielded an average aerobic heterotrophic bacterial concentration of 184 cfu/ml. However, the corresponding concentration in output water was considerably higher, being on the average in water from the three-in-one air/water syringes and cup fillers in 12 chairs 8200 and 4300 cfu/ml, respectively. Dental unit water obtained from 18 separate reservoir-supplied units in general practices in the Dublin area yielded an average of 66,000 cfu/ml. In a controlled study, once weekly overnight disinfection using either agent reduced the bacterial concentration to below the ADA recommended level. However, once disinfection ceased the bacterial loads increased to unacceptably high levels within 3 weeks. Electron microscopic analysis showed that both hydrogen peroxide-based disinfectants markedly reduced biofilm in the DUWs, but the biofilm rapidly became extensive again when weekly disinfection ceased. While both disinfectants were equally effective in lowering the bacterial counts to acceptable levels, Sterilex Ultra was associated with clogging of DUWs in some dental chair units after repeated usage, suggesting that Sanosil is a more suitable agent for routine use. Similar results were obtained by Jackson *et al.* [8] and Linger *et al.* [12].

Five chemical disinfectants were evaluated to compare their abilities to improve dental unit waterline quality and assess their effects, if any, on the biofilm layer. Sixty new dental units, with a closed-circuit water system, were used to compare microbial levels in DUWs treated with Listerine, Bio 2000, Rembrandt, Dentosept, sodium fluoride, and sterile distilled water alone as a control over a 6-week period. For all units, the waterlines were filled with solution, left overnight, and then flushed for 30 seconds with sterile distilled water the following morning prior to patient treatment. Results of this study showed that even in a closed-circuit water system, distilled water alone cannot reduce microbial contamination of dental treatment water from dental unit waterlines to the 200 cfu/ml ADA stated goal. However, water treated with 5 antimicrobials, did meet the microbial reduction goal. The biofilm apparently was reduced in volume, but not entirely eliminated [10]. In other analysis, Kettering *et al.* [11] showed that using tap water alone or tap water with bleach did not improve water quality. The 200 cfu/ml standard was achieved using the closed water system and sterile, distilled water treated with disinfectant Bio 2000 or using Bio 2000 alone. Using 100% Bio 2000 was effective, but more costly.

Phosphate buffer-stabilized chlorine dioxide mouth rinse was shown to be effective in these short-term trials for control of waterline contamination [25].

The combination of intermittent and continuous treatment with diluted sodium hypochlorite was used to improve dental unit water quality in a clinical setting. As a result, all dental units consistently delivered water with less than 10 cfu/ml, and scanning electron microscopy at the end of the study demonstrated the lack of features consistent with biofilm formation. The success of this protocol suggests that the attainment of optimal microbial dental water quality may require a combination of approaches [9].

Shepherd *et al.* [19] demonstrated the effectiveness of hydroperoxide ion-phase transfer catalyst (HPI-PTC) cleaners and disinfectants for maintaining dental unit waterlines free of planctonic organisms. The routine weekly use of an HPI-PTC cleaner controlled dental unit waterline biofilm and reduced, with minimum effort, the microbial contamination level of water used for patient treatment to less than 200 cfu/ml.

Dental equipment such as retracting shut-off valves, preventive valves that tend to fail, or waterlines that are inaccessible, contribute to a situation in which virtually every standard dental unit contains contaminated water. Regulations and technological devices are emerging to manage dental water quality [24].

Drying and flushing are other tested methods to control the microbial dental water quality. Fiehn and Larsen [7] evaluated drying of the dental unit waterlines as a new method of controlling the bacterial biofilm therein and thereby to reduce the number of living bacteria in dental unit water. The study showed that drying of DUW did not reduce the number of cfu/ml in dental unit water below the levels found in DUW left untreated.

Cobb *et al.* [4] investigated whether time-dependent waterline flushing affects the presence of biofilm in otherwise-untreated dental unit waterlines. It was concluded that water flushing of dental unit waterlines produced a statistically significant reduction in planctonic bacteria at each time interval, compared to the baseline and between each successive time interval. However, the number of cfu after 4 minutes of continuous water flushing still exceeds the current ADA recommendations for acceptable levels of microorganisms. To improve the quality of dental water, flushing or purging the waterlines is recommended, which is demonstrated by Teixeira's study [21].

CONCLUSIONS

The results of recent studies show the importance of routine monitoring of microbiological contamination of dental surgeries and, in case of contamination, the need to apply disinfection treatment to the waterlines [15]. Further research to evaluate effectiveness, convenience on a day-to-day basis and economic aspects of various methods is required.

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