Source: Journal of Dental Hygiene, Vol. 81, No. 4, October 2007

Sampling Water from Chemically Cleaned Dental Units with Detachable Power Scalers

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Purpose. This study's purpose was to determine the effect chemical cleaning had on the microbial quality of water emitted from dental unit waterlines (DUWL), 3-way syringes, and power scalers.

Methods. Ten randomly selected dental units with attached self-contained independent water reservoirs filled with deionized water were used. An ultrasonic scaler was paired with each of the ten units. This combination was retained for the duration of the study. Water samples were collected at the beginning of the fall semester and again after two weeks. Analysis indicated unacceptable levels of microorganisms and the need for a shock treatment, which included cleanings on 3 consecutive days. Water samples were collected following the initial shock treatment and for the following 4 weeks. Weekly cleanings were performed as part of routine equipment maintenance. Water specimens from the 3-way syringes and scaler handpieces were spiral plated on R2A agar plates. Incubation was at room temperature for 7 days. Plates were examined and the number of colony-forming units per milliliter (CFU/mL) was determined for each specimen.

Results. The first sampling showed that none of the 3-way syringes and one of the power scalers produced potable water after sitting unused for 6 weeks and receiving only one chemical cleaning. Improvement was noted after the second cleaning with specimens from 8 units having bacterial levels <500 CFU/mL. Three power scalers emitted potable water. Improvements in the bacterial levels of the power scalers were noted following the shock treatment; all of the power scalers emitted potable water.

Conclusions. Practitioners should routinely treat dental units and power scalers with products that will maintain acceptable microbial water quality. Administration of a shock treatment may be necessary prior to beginning a weekly maintenance protocol. Shock treatments are beneficial if units or power scalers have not been used for an extended period of time.

Keywords: biofilm, ultrasonic scalers, waterline cleaners, waterlines

Introduction

Dentistry is unique because it is the only health care discipline that routinely uses tap water in the treatment of patients. In most cases, the water used comes from municipal utilities or from private wells. Water moves throughout the office with some going directly into the dental units and then onto and through high-speed handpieces, 3-way (air-water) syringes, and power scalers, employing a system of very thin plastic tubing. The water then enters patients' oral cavities and can become aerosolized or become part of spatter, which could place practitioners at risk for occupational exposure.[1-4]

The goal of infection control in dentistry is to reduce or eliminate exposure of patients and dental team members to microorganisms. Potential pathogens usually can come from patients and practitioners. Another source, however, could be from the environment, such as air or water.[1-3]

Dental unit water lines (DUWL) contain relatively small amounts of water, much of which is in continuous contact with the inner surfaces of the tubing. The water is not in constant motion with extended dormant periods. Movement of water varies with greatest flow being in the middle of the tubing. DUWL readily become colonized by a variety of microorganisms, including bacteria, viruses, and protozoa.[1-3]

Water entering dental units usually contains few microorganisms. However, water coming out of the unit is often highly contaminated. Proliferation of microorganisms occurs within biofilms that adhere to internal surfaces of DUWL. These microorganisms exist in 2 forms - sessile and planktonic. Sessile organisms adhere to surfaces, while planktonic microbes are present within water. Planktonic microbes are shed into the water from the adhering, sessile biofilm organisms.[1-3]

Biofilm organisms adhere because of cell surface polymers, many of which are highly hydrated exopolysaccharides commonly referred to as glycocalyx polymers. These polymers give biofilm its slimy nature. The glycocalyx provides protection and nutrition and affords a site for microbial multiplication.[1-3]

Although human oral microorganisms have been found in DUWL, the vast majority present are waterborne forms. Most waterborne organisms are of low pathogenicity or are opportunistic pathogens causing harmful infections only under special conditions or among immunocompromised individuals. Microorganisms of greatest concern are the species of *Pseudomonas*, *Legionella*, and *Mycobacterium*.[1-5]

Biofilms form quickly and serve as continuous sources of contamination for DUWL water. Flushing of lines will temporarily reduce microbial emissions, but does not remove biofilm. Use of sterile water will not reduce the level of microorganisms released. The only remedy is to effectively remove the biofilms through the application of certain chemicals. Routine use of additional chemicals will help retard biofilm development.[1-3,19]

There is no evidence that indicates any widespread public health problem from exposure to DUWL emissions.[1] However, sources of microbes causing low levels of infectious diseases are not always identified. The presence of microorganisms in DUWL water is of concern and is contrary to the goals of infection control. Because exposure to microorganisms can cause infections, it is the responsibility of dental health care practitioners to use water that has the lowest level of microbial contamination.[3]

Review of the Literature

The first report of microbial contamination of dental unit waterlines (DUWL) occurred in 1963.[6] Numerous publications have since confirmed these findings.[7-11] Most DUWL are narrow- bore plastic tubing, which carry water to handpieces, power scalers, and 3-way (air-water) syringes. These lines readily become colonized with microorganisms, which can include bacteria, fungi, and protozoa.[1-5, 11-15]

There have been numerous reports of waterborne infection involving hospital settings as well as in the community.[1,5] The most common scenarios involved direct contact with water or exposure to residual waterborne contamination of inadequately

reprocessed medical instruments. Inhalation of contaminated aerosols has also caused infections. The majority of outbreaks have involved *Legionella* and *Pseudomonas*, but the fungus *Cladosporium* has also been implicated.

Research has not indicated a measurable risk concerning adverse health effects among dental personnel or patients and exposure to dental water. There has been only one case reported in the dental literature suggesting a link between exposure to DUWL water containing *Pseudomonas aeruginosa* and localized infection in 2 immunocompromised patients. Transient carriage was noted in 78 healthy patients similarly exposed, but without any reports of illness.[7]

Research has demonstrated microbial counts above 200 000 CFU/mL within 5 days after installation of new dental unit waterlines.[16] Counts in the millions can occur. Contact could be via direct exposure of tissues or through ingestion. Much of the water used in dentistry becomes a spray, which readily becomes aerosolized.[1,5]

Although there has not been evidence of a public health problem, the presence of a large number of microorganisms in DUWL emissions causes concern. Also, it is inconsistent with accepted infection control principles.[1] Standards for drinking water quality in the United States are established by the Environmental Protection Agency (EPA), the American Public Health Association, and the American Water Works Association.[17,18] These groups have set a limit for heterotrophic bacteria at ≤500 CFU/mL in drinking (potable) water. The Centers for Disease Control and Prevention (CDC) recommends this level of bacteria as a maximum in water used as a coolant or irrigant for nonsurgical dental procedures.[1]

Some have investigated the effects of drying dental unit waterlines as a means of reduction in bacterial loads found in the dental unit water. However, results have concluded that this technique did not reduce the counts of bacteria in the water samples any more than in the control groups.[19]

For many years, the CDC recommended flushing DUWL to reduce microbial emissions.[1] However, research has demonstrated that flushing does not remove biofilms, nor does it permanently improve the quality of water used clinically.[1-5]

Because flushing cannot achieve the recommended value of ≤500 CFU/mL over extended periods of time, other interventions must be used. One method is the use of in-line micropore fil-ters, which are often positioned near the handpiece or 3-way syringe connection. There is evi-dence that some filters can produce potable water. However, there are concerns because they have no effect on biofilms present in DUWL, often require chemical or UV treatment of filtered water, and can be expensive and may need to be replaced daily or weekly. Also, it is not easy to determine when a filter loses its capacity.[1-5]

Self-contained, independent water systems (attached bottles) isolate the dental unit from municipal water. The quality of the water used can be better controlled and chemicals can be introduced into the DUWL to remove biofilms or retard its formation. Using independent water systems (even if using sterile water) without chemical treatments cannot reliably improve water quality for extended times. Such delivery systems must be maintained properly in order to achieve maximum benefit.[1-5]

Chemicals can be passed through DUWL either through a self-contained reservoir or by a metering device. The dosage and frequency of chemical use varies greatly by product. Experimentation indicates that when used correctly, chemicals can remove/neutralize biofilm and/or prevent biofilm formation. Using chemicals is time consuming and often involves purging of DUWL after use. Regimens must be strictly followed. Chemicals must be compatible with the dental unit components and various dental materials being placed using treated water.[1-5]

Studies conducted using power scalers have confirmed the use of phosphate-buffered chlorine dioxide mouthrinses as possible choices of disinfectants for waterlines and in reducing the level of biofilms as compared to water rinsing and drying methods. While reduction has been shown within recommended CDC guidelines, complete elimination of biofilm has not been accomplished.[20]

This study's purpose was to determine the effect commercially prepared disinfectant cleaning of dental unit waterlines (DUWL) had on the microbial quality of water emitted from 3-way syringes and power scalers.

Methods

Dental Units

Ten dental units were randomly selected within the Dental Hygiene Clinic at Indiana University School of Dentistry for sampling. All units were identical (A-dec, Excellence Model, Newberg, Ore) with attached, self-contained water systems (independent water reservoirs). The units had been in service for 4 years. A single, central air compressor supplied all units. Bottles were changed daily. The deionized water used came from a single source.

Cleaning of DUWL occurred at the end of the work day on Thursdays. The DUWL cleaning agent used was Sterilex (Sterilex Corporation, Owing Mills, Md), which is an alkaline peroxide- based product with a phase transfer technology. The liquid chemical stayed in the DUWL until the beginning of the next working day when the lines were purged.

Power Scalers

Two types of power scalers (Cavitron Select SPS and Model Y, Dentsply International, York, Pa) were used. The scalers are attached to any unit in the Clinic when needed. Otherwise they were held in storage. Prior to the start of this study, the scalers had never undergone cleaning with Sterilex.

DUWL Cleaning Schedule

The Dental Hygiene Clinic closes each summer for 6 weeks during which time there is no chemical cleaning of the water lines. When students are present, the dental units are cleaned on a weekly basis. However, at that time cleaning did not include the power scalers. For purposes of this study, 5 Denstsply Cavitron Select SPS (Type I) and 5 Dentsply Model Y (Type II) power scalers (See figure 1) were attached and the unit and scaler pairs were cleaned together. The unit-scaler combinations were retained for the duration of the study. (See figure 2) Water sampling of 3-way syringes and power scaler handpiece lines were performed within 3 working days after the first 2 cleanings.

Figure 1: Cavitron Units

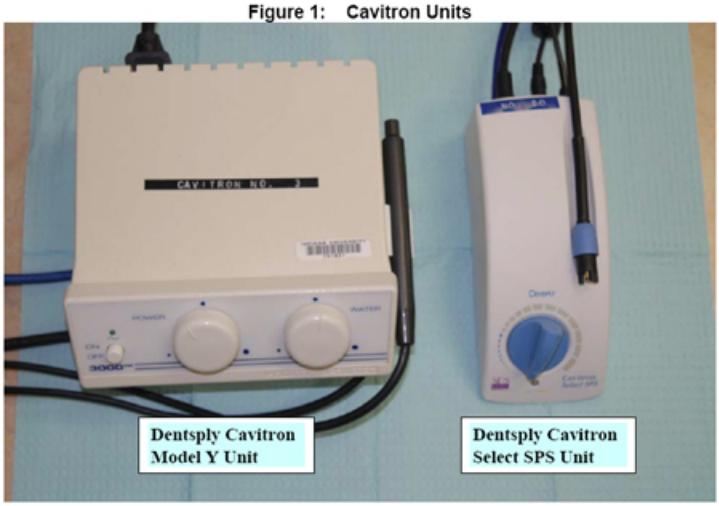

Figure 2: Example of paired Cavitron unit and water bottle

Results indicated unacceptably high levels of microorganisms and a need for a "shock treatment." This involved Sterilex applications for 3 consecutive nights to the units with the power scalers attached. Weekly Sterilex treatments were then resumed.

DUWL Sampling

Neither sterile Cavitron ultrasonic inserts nor 3-way air water syringe tips were present when collecting water samples. First, 50 mL of water from the 3-way syringe and power scaler handpiece were collected and discarded. Then, 10 mL of water from the 3-way syringes and power scalers were added to sterile polypropylene conical tubes (Falcon 15 mL, Becton Dickinson, Franklin Lakes, NJ). Similar specimens were obtained from 3 unopened bottles containing deionized water to be used on the Clinic's units. Specimens were immediately transferred to a microbiology laboratory for processing.

DUWL Specimen Processing

One tenth of a milliliter of filter-sterilized sodium thiosulfate (1.0% w/v) was added to each tube to neutralize any possible residual chlorine, thus reducing the possibility of a bacteriostatic (carry-over) effect.

Specimens were plated in duplicate using a Spiral Platter (Spiral Systems, Inc., Cincinnati, Ohio) onto R2A agar plates (Difco Laboratories, Detroit, Mich). R2A medium was developed to monitor heterotrophic bacterial populations in water treatment processes and in distribution water. Plates were incubated aerobically at 21°C for 7 days.

Following incubation, numbers of colonies on each plate were counted with the aid of an illuminated box (Spiral Systems, Inc.) and expressed as colony-forming units per mL (CFU/mL) of original specimen.

Result

Table I reports bacterial levels in water specimens obtained the first 2 weeks after the beginning of the fall semester. Weekly cleanings of the units with power scalers attached were performed.

Table I. Growth of Bacteria of R2A* Medium Prior to Shock Treatment

** Agar Plate Medium*

Testing Combinations				Testing Combinations			
Sampling 1				Sampling 2			
Dental Unit	CFU/mL[1]	Scaler type[2] & scaler unit no.	CFU/mL	Unit	CFU/mL	Scaler type[2] & scaler unit no.	CFU/mL
2	6320	Type II 9	16,200	2	540	Type II 9	12,320
3	4320	Type I 19	4480	3	2340	Type I 19	15,980
9	7380	Type II 7	120	9	360	Type II 7	15,980
10	3580	Type II 2	9420	10	6360	Type II 2	18,220
11	6280	Type II 15	15,669	11	360	Type II 15	13,880
12	1820	Type I 5	11,300	12	40	Type I 5	220
13	1420	Type II 12	14,260	13	120	Type II 12	6840
16	6280	Type I 2	3320	16	160	Type I 2	60
17	12,240	Type I 14	3820	17	0	Type I 14	0
20	4380	Type I 19	3220	20	380	Type I 19	5980
AVE	**5402**		**6152**	**AVE**	**1065**		**8948**

1CFU/mL = colony forming units per milliliter

2 Scalers: Type I = Dentsply Cavitron Select SPS ; Type II = Dentsply Model Y

Average of Supply bottles Sampling 1 = 2812 CFU/mL

Average of Supply bottle Sampling 2 = 392 CFU/mL

Water recommended for use in dentistry should contain ≤ 500 CFU/mL. In the first sampling, none of units emitted acceptable water. Levels varied widely, from 1420 CFU/mL to 12 240 CFU/mL. Only one of the power scalers produced potable water. Again, bacterial levels were quite variable. Water specimens were obtained from 3 unopened water bottles. The average of the bacterial counts for these bottles was 2812 CFU/mL. This confirmed that levels of the bacteria emitted from the units with scalers attached were unacceptably high and greatly exceeded the CDC's recommended levels.

Improvement was noted for 8 of the 10 units after the second cleaning with specimens from 8 of the 10 units having bacterial levels ≤ 500 CFU/mL (Table II). Only 3 power scalers (all SPS) emitted potable water. The average for bacterial counts for the 3 supply bottles tested was 392 CFU/mL. Table II reports bacterial counts of the units with 2 types of scalers attached following the shock treatment and the weekly cleanings. However, not all of these results were within acceptable levels according to the CDC guidelines.

Table II. Growth of Bacteria on R2A* Medium After Shock Treatment **Agar Plate Medium*

Testing Combinations

Sampling 1				Sampling 2				Sampling 3				Sampling 4				Sampling 5			
Dental Unit	CFU/mL [1]	Scaler[2] type & unit no.	CFU/mL	Dental Unit	CFU/mL	Scaler type & unit no.	CFU/mL	Dental Unit	CFU/mL	Scaler type & unit no.	CFU/mL	Dental Unit	CFU/mL	Scaler type unit no.	CFU/mL	Dental Unit	CFU/mL	Scaler type & unit no.	CFU/mL
2	0	Type II 9	0	2	0	Type II 9	0	2	0	Type II 9	0	2	0	Type II 9	0	2	0	Type II 9	0
3	2600	Type I 19	0	3	0	Type I 19	0	3	0	Type I 19	0	3	160	Type I 19	0	3	880	Type I 19	0
9	0	Type II 7	0	9		Type II 7	0	9	0	Type II 7	0	9	0	Type II 7	0	9	0	Type II 7	0
10	0	Type II 2	0	10	3200	Type II 2	0	10	40	Type II 2	0	10	0	Type II 2	0	10	2500	Type II 2	0
11	0	Type II 15	0	11	0	Type II 15	0	11	0	Type II 15	0	11	0	Type II 15	0	11	2000	Type II 15	0
12	0	Type I 5	0	12	0	Type I 5	0	12	0	Type I 5	60	12	0	Type I 5	0	12	0	Type I 5	0
13	0	Type II 12	0	13	2000	Type II 12	0	13	0	Type II 12	0	13	0	Type II 12	0	13	2600	Type II 12	0
16	0	Type I 2	0	16	0	Type I 2	0	16	0	Type I 2	20	16	0	Type I 2	20	16	1200	Type I 2	0
17	0	Type I 14	0	17	0	Type I 14	0	17	0	Type I 14	20	17	120	Type I 14	0	17	0	Type I 14	0
20	0	Type I 19	0	20	0	Type I 19	0	20	0	Type I 19	0	20	0	Type I 19	0	20	1400	Type I 19	0
AVE	260		0	AVE	500		0	AVE	4		10	AVE	28		2	AVE	1058		0

1CFU/mL = colony forming units per milliliter

2 Scalers: Type I = Dentsply Cavitron Select SPS ; Type II = Dentsply Model Y

Discussion

This study set out to investigate the prevalence of microbial contaminations within ultrasonic scaling units and air-water syringe waterlines and methods by which control of these contaminations may be accomplished and maintained. Based on our results, we have demonstrated that levels of microorganisms from the ultrasonic units' waterlines remain high and at unacceptable levels for public safety, well above the CDC Guideline of 500 CFU/mL. After shock treatment and weekly cleaning, all water specimens from both types of scalers had acceptable bacterial levels according to the guidelines. No culturable bacteria were obtained from ninety-two percent of the power scalers during the timeframe of the study. Practitioners should consider routine flushing of the ultrasonic waterlines as well as the air-water syringe waterlines with disinfectants. What remains unclear is how often the water lines should be "shocked" and how often a maintenance level of disinfectant is to be used. Although the results showed that using protocols similar to those demonstrated in the study does reduce microorganisms, the results of the collected data were mixed.

Varied results in levels of contamination were discovered at both the initial collection phases and following administration of disinfectants. Human error in collection of data and in administration of the disinfection protocol could have impacted these results. Administration of any disinfecting mechanism for the maintenance of water lines for air-water syringes and ultrasonic scalers is technique sensitive. Close adherence to recommended guidelines and schedules is critical. Additional studies may consider more clearly defined protocols for administration of disinfectants to waterlines for biofilm control. In addition, the water supply used for the closed water systems on the dental units utilized water treated by deionization and filtration. This process does not equate to sterile water. It is possible that contaminants in this source contributed to the uneven results. Further study may consider the use of sterile water for systems as an alternative to a reverse osmosis system in order to reduce biofilm. Another possible reason for the varied results may be the water bottles themselves, although they are cleaned with soap and water after each use. It is possible that the bottles are a contributing source of contamination. The opening of the bottle is small, making routine disinfection difficult. Further study may clarify this issue and propose solutions for this dilemma.

Conclusion

Results of the study suggest that when using Sterilex as a line cleaning agent treatment for ultra sonic scalers should include administration of an initial shock treatment followed by routine weekly maintenance should be included. This practice resulted in the emission of potable water for the 4-week duration of the study. Ultra sonic water line maintenance should be an integral part of every infection control program.

Acknowledgements

The authors would like to thank Tuwana Ivy, clinic clerk for IUSD's Department of Dental Hygiene for her assistance during this study. The authors would also like to thank IUSD second-year dental hygiene students Erin Hudson, Samantha Judge, Casey McClain, and Leah Taylor for their efforts in completing the clinical aspects of the study.

Notes

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