SCIENCE REGARDING DENTAL UNIT WATERLINES (DUWL): A REVIEW

*Sanjeev Tyagi **Parimala Kulkarni ***Krisna Prasad P

*** Professor, Department of Conservative Dentistry and Endodontics, People's Dental, Academy, Bhopal.***
** Professor,Department of Pediatric Dentistry, People's Dental Academy, Bhopal*
*** Reader, Department of conservative of Conservative Dentistry and Endodontics, Chattisgarh Dental College, Rajnangaun, Chatiisgadh*

ABSTRACT

Water is used as a Coolant and irrigant for various dental procedures. This water that flows through the Dental Unit Water Line (DUWL) should be free of contamination. The microorganisms contaminating the dental unit supplies is different from those which contaminate the drinking water. This article reviews the different provisions to be made in the water pipeline systems to prevent contamination

KEYWORDS: ***Contamination, Dental Unit Water Line (DUWL)***

INTRODUCTION

A preponderance of scientific evidence has documented that the water used as a coolant and irrigant during dental procedures can be heavily contaminated with microorganisms.[1] The provision of dental unit waterline (DUWL) that is safe for use with all categories of patients is now an essential issue world-wide that units both Dental Governing Bodies and dental equipment manufactures.

Internationally, legislation on water microbiological quality is based on the coliform count; an indicator of sewage or faecal contamination of drinking water. Safety standards do not exist however, for the quantification of opportunistic Gram negatives bacterial species or respiratory pathogens that are found in low numbers in the main water supply. In dental unit supply lines these are the species which constitute numerically the most important organisms found in DUWL.[2]

Dental water may be ingested, inhaled in the form of aerosols or directly contaminate surgical wounds. It is not unusual for dental coolant water and aerosols, entering the patient's mouth to contain large numbers of organisms in the range 10^4 to 10^8 colony forming units (cfu)/ml.[3] This water if judge by drinking water standards set in Japan of 100 cfu/ml, Europe < 200 cfu/ml and America of <500 cfu/ml, would not be considered fit for human consumption.[2]

Several studies have indicated that dentists and dental staff have higher rates of respiratory infection than the general public.[2] [3,4] Contaminated handpieces are believed to be at least partially responsible for these higher rates of respiratory disease.[5] Appropriate procedures to decontaminate handpiece, including autoclaving and handpiece replacement between patients; have been developed and implemented in dental practices.[4,6,7] These procedures are aimed at reducing the likelihood of aerosol dissemination of pathogens

within dental operatories and the resulting infections. However, decontamination of handpieces such as high speed drills and syringes does not remove the potential for exposure to pathogens that originate within the water lines of dental units.[8]

Creation of biofilms in DUWL:

Biofilms are microbial communities that adhere to solid surfaces wherever there is sufficient moisture (including plant and animal tissues). Most plastic dental tubing has an inside diameter of $^1/_{16}$ to $^1/_8$ inch, and thus has a very large surface area to volume ratio. The hydrophobic surface of waterline plastic promotes the attachment and colonization of biofilm organisms. At peak usage, the flow rate in a dental handpiece can be between 2 to 10 ml per minute. In contrast, most household water pipes are made of ½ inch diameter copper with flow rates of about 5-liters per minute. This is approximately 1,000 times greater than the flow through dental unit waterlines. The water in the dental lines is also completely stagnant on weekends and evenings.

The layered structure of biofilms (limited diffusion) combined with the low flow conditions renders these microbial colonies intrinsically resistant to many biocides and cleansing schemes. Active biofilm then become the primary reservoir for continued contamination of the system.

Biofilms also provide an environment conducive to the proliferation of a wide a variety of other microscopic life, including fungi, algae, protozoa and nematodes [9].

The formation of biofilms on water bearing surfaces in dental units results in fouling of the water that passes through the unit with high levels of suspended bacteria. Most organisms recovered from dental water system are gram negative non coliform water bacteria.[10,11,12]

Research to date suggests that whichever method is used, microbial recolonisation of the waterline is inevitable and repeat disinfecting treatments are necessary. We suspect that this is mainly because of the complex design of dental chair equipment resulting in the stagnation of water within the equipment lines where bacteria, including Legionella species could proliferate within a biofilms.[13]

Relative Risks to patients:

Currently there is no clinical evidence of a widespread public health problem from exposure to DUWL. Nevertheless, the goal of infection control is to minimize the potential risk from exposure to known pathogens and to create a safe working environment in which to treat patients. The ever increasing number of patients who are either immunocompromised or immunosupressed due to steroids, drug therapy, alcohol or systemic disease has produced a substantial number of patients susceptible to environmental, water borne opportunistic pathogens such as those found in DUWL.[9]

Risk to Dentist:

The clinical members of the dental team inhale aerosols generated by dental equipment on a daily and long term basis. Abnormal nasal flora in dental personnel has been linked to water system contamination. Studies have indicated that the clinical dental team suffers from more respiratory infections compared to their medical colleagues or the general public.[9] Dentist have higher rates of antibodies to Legionella compared with the general public. The magnitude of Legionella antibody titres correlated directly with the number of years spend working in a dental surgery, suggesting that aerosols generated from DUWL are the likely source of exposure [14]

Organisms present in DUWL

Many early researchers assumed that most of the organisms they found in dental water were retracted from the oral cavity.[15,16] On the basis of this assumption, they often used culture media and incubation methods designed to recover human flora .[15,16] While organisms consistent with oral flora are recovered, the majority of microbes living in the biofilm communities are gram-negative water bacteria of the same varieties that survive in small number in municipal system.[16]

As biofilms mature, they provide a hospitable environment for fungi, protozoa and other organisms that survive in drinking water systems.[9] While most of these organisms have minimal pathogenic potential in immunocompetent hosts, some protozoa serve as hosts for proliferation of parasitic bacteria including Legionella.[14,17] Pseudomonas aeruginosa has been reported as being present in dental units.[10] This gram negative rod is associated with a wide range of opportunistic infection and is a cause of pneumonia in hospitalized patient. Only pseudomonas aeruginosa derived from DUW has definitely been shown to cause oral infection in patients.[2] High numbers of non-tuberculous mycobacterium may be swallowed, inhaled or inoculated into oral wounds during dental treatment with the potential for colonization, Infection or immunization.[2]

Legionella pneumophila and related species also have been isolated in DWL. These weakly staining bacteria thrive as intracellular parasites of protozoa. They are the causative agents for legionnaires disease and a relate condition known as Pontiac fever.

Aquatic nontuberculous mycobacterium species associated with pulmonary disease and opportunistic wound infections also have been recovered in dental unit water.[3]

Recommendations for DUW:

Researchers beginning with Black[18] in 1963 have investigated treatment options intended to maintain of dental treatment mater.

No currently available single method or device will completely eliminate contamination of DUW or prevent the risk of cross infection. To reduce contamination a combination of methods need to be used. The recommendations for DUW are:

1. Water supplying dental units should have a total colony count of <200 cfu/ml and comply with local drinking water standards.
2. For surgical procedures use sterile irrigant water or saline provided from a separate and preferably single use source.
3. Existing recommendations for flushing through of water lines between patients and at the beginning and end of the working day, eliminate oral flora entering the water lines via suck-back but only partially and temporally reduces the existing bio-burden in the DUW.
4. Anti-retraction valves should be incorporated on all hand pieces or waterlines and must be regularly monitored and maintained.
5. Independent water reservoirs when used with sterile water are capable of delivering water with <200 cfu/ml total count. This can only be achieved if manufacturer's instructions regarding disinfection by purging the line with biocide are adhered to.
6. To reduce biofilm proliferation and overnight water stagnation, drain down the waterlines at the end of the day.[2]

Quality Improvement methods for DUW

Efforts are under way to develop national standards for products intended to improve the quality of dental treatment mater. In 1994, the ADA standards committee on dental products began work on a specification for antimicrobial agents and other chemicals for the prevention, inactivation and removal of biofilm in dental water system. Proposed American National Standards Institute/ADA specification No. 107 for Antimicrobial agent and other chemicals for Prevention, Inactivation and Removal of biofilm in dental unit water system addresses efficacy, biosafety and compatibility of the various chemical agents with dental equipment and materials.[18] Most strategies to improve the quality of water provided by conventional dental units employ the use of chemical treatment either alone or in combination with other technologies, including microfiltration. Another alternative is to entirely bypass the conventional dental water delivery system and use either autoclavable or disposable pathways.

Waterline flushing:

Flushing was introduced as a simple and expedient measure, that could be instituted immediately as a stop gap procedure in all dental surgeries of whatever age or type without the need to purchase additional equipment.[2] Although flushing can temporarily reduce the number of organisms suspended in DUWL's there is no predictable effect on adherent biofilm. ADA's and BDA's recommendations state that water lines should be flushed through for several minutes at the start of each clinic day to substantially reduce microbial accumulation caused by overnight stagnation in the waterline.[2]

Discharging the stagnant water improves the perceived quality of the water by reducing the malodour and bad taste imparted to the water by microbial contamination, flushing is valuable in eliminating retrograde aspiration of oral fluids.[2]

The efficacy of mechanical flushing alone to control microbial contamination in dental unit water line is not well supported by the scientific literature[3,12,19,20,21]. Although lushing can temporarily reduce the number of organisms suspended in DUWL's, there is no predictable effect on adherent biofilm.[22]

Filtration:

Using filters on the dental waterline was first described 20 years ago to reduce planktonic (suspended) bacteria. Micropore membrane filters are used to remove microorganisms from water and solutions in a wide range of medical and industrial applications.

If the units are connected to municipal water supplies, the water also may contain impurities including minerals, organic compound and endotoxin, that are not always removed by filters. Therefore, even when water produced by filtration in the dental clinic is bacteria free, it should not be used in place of sterile water in surgical procedures.[22]

Two independent evaluation of microfiltered water used in dentistry found that 80 percent of output water samples were bacteria-free, and none of the remaining specimens exceeded 200 cfu/ml. of heterotrophic plate count bacteria. [19,23]

Murdoch-Kinch and colleagues[24] found that use of 0.22 micro m. filters resulted in fewer numbers of organisms observed on scanning electron microscopy in post filtration tubing sections than in prefiltration sections.

Mayo and Brown[23] found no detectable organisms in water samples taken immediately downstream from 0.2 micro m proprietary filters; however, when they increased the distance at which the filter was placed from the air water syringe, levels of bacteria in effluent water increased, probably owing to the formation of biofilm in the post filtration waterlines.

Installation of filter housing on each water-bearing line as close as possible to the H/P or water syringe. In addition units may remain connected to municipal water supply.

Independent Reservoirs:

By isolating the dental unit from the municipal water supply, the clinician can control the quality of water introduced into the system. The user can introduced cleaners and germicides to control on eliminate biofilm formation within the water delivery system[1], without treatment with chemical agents to inactivate or detach biofilm or installation of point-of-use filters, independent reservoirs are of little valus in improving the quality of treatment water.[22] Independent reservoirs are relatively inexpensive to install compared with other devices.

Sterile water Delivery System:

Irrespective of the agent used to treat the system, the quality of water delivered can be no better than the source water used in the reservoir bottle. Sterile water delivery system are designed to provide irrigation during surgical or implantation procedures. These systems employ single used disposable or autoclavable tubing to bypass the dental unit and provide sterile irrigating solutions directly to dental hand pieces. Their disadvantages include higher purchase coasts and their need for packaged sterile solutions.[1]

Chemical Treatment:

An ideal agent for control of biofilm would be bactericidal but not toxic or irritating to humans. And, of course to be truly ideal, it would be inexpensive and easy to use, should discourage subsequent reformation of biofilm, while protecting the dental unit's internal components from corrosion or degradation.

Chemicals may be introduced into water system either intermittently or continuously. Most intermittent treatment regimens use potentially biocidal concentrations of germicide that also may remove biofilm. A major advantage of intermittent chemical use is that the active agent is purged from the system before patient treatment. Disadvantages include the potential for surviving biofilm organisms to rebound between treatments, potential staff exposure to chemicals, and the potential for adverse impact on metal, rubber and synthetic dental unit components.

Although continuous treatment offers less potential for recolonization of waterlines, it still may damage equipment. Since the agent is always present and may be aerosolized, the effects of chronic exposure on the health care worker must be considered. Enamel and dentin bound strength of dental adhesive materials also may be affected. [13,25]

Chlorination:

Chlorine, as sodium hypochlorite is the most commonly employed biocide in water and has proven efficacy is hospital cold water system in particular for controlling Legionella proliferation. In some environments Legionellae are able to increase their chlorine resistance by 30-120 folds by living inside amoebae, often resulting in failure to eradicate the organism. Potentially higher doses of 3-5 ppm could overcome this problem.[2]

Disadvantage of long term exposure to chlorine include bacteria developing resistance, corrosion damage even at 1ppm formation of trihalomethanes (potential carcinogens) and that high chlorine levels are unpalatable.[10]

Biocides and chemical disinfectants:

Biocides (compounds with lethal activity against living organisms) are used to remove the biofilm and eliminate the plank tonic bacterial count. Their use has met with a limited degree of success[2]. Different biocides for use in dentistry including sodium hypochlorite, chlorhexidine gluconate, povidine iodine, ethanol, peroxide and glutaraldehyde. Integral automated flush system employing glutaraldehyde are commercially available but its sensitization of the human lung and skin have severely limited the use of this compound in dentistry.[2]

Peroxide, Ozone UV:

Bacteria from the biofilm are shed continually while the film is in contact with water. Thus compound such as UV, H_2O_2 and ozone are advantages in that they can be introduced continuously into the water line during patient treatment thus maintaining low levels of plonktonic counts throughout the working day. Unfortunately, the published efficacy data on H_2O_2 and ozone with regard to purification of DUWL is limited at the present time.[2] UV irradiation alone has a significant effect on reducing microbial contamination is equivocal due to the relative resistance of some important waterborne pathogenic species.

A major advantage of these systems is that they avoid introducing chemical disinfectants into the effluent water system with their associated potential for pollution and destructive effects on wildlife.[2]

Autoclavable systems:

A fully autoclavable assembly of water reservoirs, silicon multi-lumen dental unit waterline tubing and fitting that can be sterilized between patients has been produced and cleared for marketing by the food and drug administration in the USA. Auto-clavable systems may be the solution to providing secure, sterile mater systems.[2]

CONCLUSION:

Since the origins of dental unit water contamination are now more clearly defined, substantial progress can be made by dental manufacturers and the scientific community in approaches to prevention and control.

DUWL cleanliness is not a public health crisis. Nevertheless, water that is unfit to drink as defined by nationally recognized standard is unsuitable for therapeutic use is dentistry. Prudent clinicians should consider the following recommendations.

- Review the scientific literature to keep current on new developments and be prepared to answer questions from patients and staff.
- Use only sterile fluids for surgical procedures.
- Contact the equipment manufacture or dealer to obtain current recommendations for improving and manufacturing water quality.
- When purchasing new equipment, select products that can reliably and economically maintain good water quality.[22]

More research is needed, however, to determining the constitutention and pathogencity of microbial biofilm and the actual contribution of exposule to obtain on human disease.[1]

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Corresponding Author:

Sanjeev Tyagi
Professor
Department of Conservative Dentistry & Endodontics,
People's Dental Academy,
Bhopal, Madhya Pradesh.
E-mail;drtyagis@gmail.com