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Research Article

"DENTAL AEROSOLS" – ROLE OF ITS REDUCTION IN INFECTION CONTROL – AN IMPORTANT REVIEW

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ABSTRACT
All procedures performed with the use of dental unit handpieces cause the formation of aerosol which are commonly contaminated with bacteria, viruses, fungi, often also with blood. Aerosol is defined as small droplet usually 5µm or less in diameter, which can remain suspended in air for some time. All dental personnel including dentists, nurses, and hygienists are at risk from contaminated dental aerosols. Thus here author reviews role of its reduction in infection control. The authors reviewed representative medical and dental literature for studies that documented the spread of disease through an airborne route. They also reviewed the dental literature for representative studies of contamination from various dental procedures and methods of reducing airborne contamination from those procedures. This review highlights the dental aerosols hazards experienced by dental personnel. However, focus is directed on exposure to biological agents as a result of fine aerosol during dental procedures and aims towards standard precautionary measures to minimize risk. Dental procedures contributed to increased bacterial contamination at the working environment from contaminated aerosols that may pose a health risk both for dental personnel and patients hence Standard precautionary measures to be taken minimize risk.

Keywords: *Dental Aerosols/Air Born Contamination/Dental Procedure/dental Chair Unit/Infection Control*

INTRODUCTION
It was felt that diseases could be spread by noxious vapours in the air. This belief is reflected in the name of the disease malaria. In Latin, the word malaria literally means "bad air." In the case of malaria, it was discovered that the disease was spread by mosquitoes that flew in the night air rather than the night air itself (Stephen and Harrel, 2004). Possibly due to the fact that many historical diseases were eventually shown to spread primarily through a non-airborne route, the control of airborne infections has not been stressed in many infection control protocols (Stephen and Harrel, 2004).
Current health issues such as the continuous changes in HIV/AIDS rates, the increase in number of people infected with the hepatitis C virus, the re-emergence of tuberculosis, new viral diseases, the increase in number of people with respiratory infections, the recent outbreak of Severe Acute Respiratory Syndrome, H1N1 influenza and the number of immuno-compromised individuals seeking dental care has triggered a re-evaluation of infection control procedures (Toroglu *et al.*, 2003).
Research studies have demonstrated that infective hazards are present in dental practice, because many infections can be transmitted by blood or saliva through direct or indirect contact, droplets, contaminated instruments equipments and dental aerosols (Merchant, 1991).
Aerosol is defined as small droplet usually 5µm or less in diameter, which can remain suspended in air for some time. All dental personnel including dentists, nurses, and hygienists are at risk from infectious agents. Previous seroepidemiological studies have confirmed these occupational hazards (Azari *et al.*, 2008).
Showing higher concentrations of serum antigen and antibodies for hepatitis B (Panis *et al.*, 1986), hepatitis C (Thomas *et al.*, 1996), and Legionella species (Reinthaler *et al.*, 1998), in dentists than in the other population. Increased prevalence of respiratory infections (Davies *et al.*, 1994) as well as symptoms possibly related to aerosols and droplets in the air of their breathing zone at work (Allsopp *et al.*, 1997).

Researchers have studied the bacterial contamination of air samples collected from dental offices and stated that infectious aerosols may be generated during dental practice, especially when high-speed hand dentistry tools are used without a high-volume evacuator (Legnani *et al.*, 1994). There are data that support the potential transmission of infectious diseases through inhalation of these aerosols (King, 1997). The American Dental Association, the Centre for Disease Control and Prevention, and the Organization for Safety and Asepsis Procedures have issued recommendations for the reduction of dental aerosols. Though invisible to the human eye, aerosols can potentially cause severe diseases to both oral health care workers and their patients.

Potential Sources of Air Borne Contamination during Dental Treatment

A. Saliva, Blood and respiratory sources (patient itself)
B. Dental Instrumentation
C. Operative sites

A. Saliva, Blood and Respiratory Sources (Patient Itself)

In many routine dental procedures, high-speed air-driven dental hand pieces are used for various purposes. All high-speed dental hand pieces produce a significant amount of frictional heat at the working tip. Considerable amounts of coolant water are needed to cool the tip to prevent heat transfer to the tooth surface. The presence of coolant water or other fluid to cool and lavage the working site is responsible for the negative side effects of producing a large amount of aerosol and the collection of excess water in the patient's mouth (Finkbeiner and Claudia, 1995).

The water coolant system is designed to operate within the hand piece and allows for an automatic flow of water, when the dental hand piece is activated. The concept used in most designs allows the water spray to hit the working tips as it rotates on the tooth surface. The coolant water interacting with the working tip produces an aerosol spray, which comes in contact with fluids such as saliva, blood, or gingival fluid, producing the aerosol suspension of fine particles (Finkbeiner and Claudia, 1995).

It has been shown in the literature that high-speed dental hand pieces produce an increase in the number of bacterial colony– forming units (Belting *et al.*, 1964) and that bacteria can be recovered 6 to 12 inches from the mouth of the patient. Airborne infective microorganisms in the form of infectious aerosols may be inhaled, thus causing diseases such as influenza, the common cold, and tuberculosis (Abbott *et al.*, 1955).

Dental treatments are often performed in the presence of gingival inflammation and bleeding. Saliva is of particular concern during dental treatment because it is frequently contaminated with blood. Although blood is not visible in the saliva, it may be present. When a high-speed dental hand piece is used in the presence of blood, it is logical to think that the blood is aerosolized and incorporated into the larger volume of aerosol cloud associated with the coolant water and can remain airborne for a significant time. Therefore, there may be a risk that the aerosols contain hepatitis B virus (HBV), hepatitis C virus (HCV), and hepatitis D virus, which can be found in the blood of patients with hepatitis.

Aerosols generated by high-speed dental hand pieces and composed of various combinations of coolant water, tissue, tooth dust, blood, and saliva could contaminate skin, mucous membranes of mouth, eyes, and respiratory passages of dental personnel. Mucosal contact, non intact dermal contact, and parenteral contact with potentially infectious materials are generally the accepted routes of infections. Mouth is a part of oro-nasal pharynx. As part of this complex, the mouth harbors bacteria and viruses from the nose, throat and respiratory tract. Any dental procedure that has the potential to aerosolize saliva will cause airborne contamination with organisms from some or all of these sources (Bently *et al.,* 1994; Miller and Micik, 1978; Miller, 1995).

Procedures Shown to Produce Airborne Bacterial Contamination

Ultrasonic and sonic scalers; Shown to be the greatest source of airborne contamination, Air polishing; Bacterial counts shown that airborne contamination is nearly equal to ultrasonic scalers, Air-water syringe; Bacterial counts indicate that airborne contamination is slightly less than ultrasonic scalers, Tooth preparation Airotor; Bacterial counts shown that airborne contamination is nearly equal to ultrasonic scalers (Harrel and Molinari, 2004).

B. Dental Instrumentation

In dentistry, the dental chair unit (DCU) is the most essential item of equipment necessary for the practice of dentistry. Over the last 40 years, the function of the DCU has developed from simply providing physical support to advanced designs and configurations that are comprised of several complexes, integrated equipment systems, which provide all of the services (e.g., water, air supply, electric power and suction) and dental instruments required for a wide range of dental treatment procedures. Dental instruments connected to DCUs (e.g., ultrasonic scalers, air scalers, high-speed turbine dental handpieces, and conventional dental handpieces) are cooled by DCU-supplied water, which also supplies three way air/water syringes to irrigate and cool tooth surfaces during dental treatment. In addition, water is also supplied to the DCU cup filler outlet that is used by patients for oral rinsing and to the bowl-rinse outlet that rinses the DCU spittoon. Each DCU is equipped with an elaborate loom of interconnected narrow-bore (i.e., mostly 2–3 mm internal diameter) flexible plastic tubing called dental unit waterlines (DUWLs) that supply water to all of the DCU-supplied instruments, cup-filler and bowl-rinse water outlets . In a typical DCU, the DUWL network can consist of many meters of tubing. Due to the texture and composition of the plastic tubing, microbial biofilms form readily, resulting in DCU output water that is frequently heavily contaminated with microorganisms (O'Donnell *et al.,* 2011).

Contamination of Reservoir Bottles

Some DCUs use independent water reservoir bottles to provide water to the DUWLs. These bottles are manually filled with water (mains water, distilled water or sterile water) but can easily become contaminated with skin bacteria such as *Staphylococcus epidermidis* and *S. aureus*, the latter a common human pathogen, thus introducing additional human microorganisms into DUWLs (O'Donnell *et al.*, 2011).

Microorganisms found in DUWL Output Water

Environmental Microorganisms

Fungi, yeasts, protozoa and amoebae can also be present in DUWL output water, although contamination by these microorganisms is less prevalent and the organisms are present at lower densities than bacteria Known human bacterial pathogens recovered from DUWL output water include *Pseudomonas* species, particularly *Pseudomonas aeruginosa*, *Legionella* species, particularly *L. pneumophila* and non-tuberculosis mycobacterial species (Putnins *et al.,* 2001).

Human-derived Microorganisms

As outlined in the previous sections, oral and skin bacteria have been reported in contaminated DUWL output water, most likely owing to retraction of oral fluids into DUWLs following DCU instrument use in the oral cavity and from contamination of reservoir bottles or bulk storage containers with skin squames when bottles are being handled or filled (Pankhurst and Coulter, 2007).

Endotoxins

Dental unit waterline output water can be a major source of bacterial endotoxins (lipopolysaccharide) released from the cell walls of Gram-negative bacteria. Levels up to 100,000 endotoxin units (EU) per ml have been reported in DUWL output water (Singh *et al.,* 2010).

Inhaled endotoxin can exacerbate air flow obstruction and airway inflammation in individuals with allergic asthma and asthma severity is directly correlated with concentration of endotoxin (Michel *et al.*, 1996).

In medical devices that are prone to biofilm growth and endotoxin accumulation such as humidifiers, a hypersensitivity pneumonitis due to endotoxin exposure is well recognized (Pankhurst and Coulter, 2007). A study indicated that endotoxin present in DUWL output water might stimulate the release of pro-inflammatory cytokines in gingival tissue during oral surgery and adversely affect healing (Putnins *et al.,* 2001).

If reservoir bottles are supplied with distilled water, the microbiological quality will be influenced by the condition and cleanliness of the distilled water storage containers. Temperature and the presence of suspended material, particulate matter, organic material and suspended and dissolved inorganic compounds in DCU supply water can directly affect the development and proliferation of biofilms within DUWLs (O'Donnell *et al.,* 2011).

DUWL output water is usually swallowed in small amounts during treatment and aerosols generated by dental instrument use are inhaled. Therefore, the microbiological quality of DUWL output water should be such that potential cross-infection risks and other health risks are minimized (O'Donnell *et al.,* 2011).

C. Operative Sites

In a study, the air samples of dental surgery rooms have been studied. The microbial density of indoor air was fairly high compared to non-pathogenic indoor air criteria. Staphylococcus species were found in indoor air of dental school and the active role of dentistry operations in microbial contamination of various parts of the dental school with or without direct involvement with dental operations was noticed. This could be due to the frequent use of devices with propelling force such as a high-speed dental drill combined with a water spray, which can generate numerous airborne infectious microbial agents. The total bacterial counts in the air of dental surgery rooms and in non-surgery rooms without direct involvement with dental operations were in the range of 120-280 cfu/m3 and 49-128 cfu/m3, respectively. Staphylococcus bacteria were found in all areas of the dental school. The total fungi counts in the air of dental surgery rooms and in general rooms without direct involvement with dental operations were in the range of 1-50 cfu/m3 and 1-4 cfu/m3, respectively (Azari *et al.,* 2008; Harrel and Molinari, 2004).

According to the data presented for indoor microbial air contaminants in this study, there is a potential transmission route for infectious agents to be transmitted to dental personnel and the presented data support the importance of protection against cross-infectious agents present in dental aerosols (Azari *et al.,* 2008; Harrel and Molinari, 2004).

Methods of Reducing Airborne Contamination

Centers for Disease Control and Prevention; Guidelines for infection control in dental health-care Settings are Facemask and face shield; masks should have at least 95% filtration efficiency for particles 3.0-5.0µm in diameter. should be changed for each patient, change of mask after 20 minutes in aerosol or 60 minutes in non aerosol environments, routine part of "standard precautions," masks will only filter out 60% to 95% of airborne contamination, inexpensive, subject to leakage if not well fitted, does not protect when mask is removed after the procedure. Eye Protection Protective eye wear or face shield must be worn while treating patients (Centers for Disease Control and Prevention, 2003).

Use of Pre-Procedural antiseptic mouth rinse (0.2% Chlorhexidine, Povidone Iodine) (Logothetis and Martinez-Welles, 1995; Muir *et al.,* 1978) reduces the bacterial count in the mouth, saliva, and air. It is an inexpensive on a per patient basis. Tends to be most effective on free floating organisms, It will not affect on biofilm organisms such as plaque, subgingival organisms, blood from the operative site or organisms from the naso-pharynx.

High volume evacuator (HVA); will reduce the number of bacteria in the air and remove most of the material generated at the operative site such as bacteria, blood, and viruses, inexpensive on a per patient basis. When an assistant is not available, it is necessary to use an HVE attached to the instrument or a "dry field" device. A saliva ejector is not an HVE and does not control aerosols.

HEPA (High-Efficiency Particulate Air) room filters and UV treatment of ventilation system, **e**ffective in reducing numbers of airborne organisms, only effective once the organisms are already in the room air. Moderate to extremely expensive, may require engineering changes to the ventilation system.

Four methods are now widely advocated to reduce the level of bacterial contamination in dental water; 1. Flushing waterlines for several minutes at the beginning of the day and after periods of disuse; 2. Using an independent water reservoir system separate from the municipal water source (sterile water); 3. Use of an independent water reservoir system combined with periodical or continuous application of chemical germicides; 4. Use of microfiltration to trap microbes before they reach the dental client (Bednarsh *et al.,* 1996).

To preserve the appropriate water quality in DUWL, water stasis in the tubes should be limited in order to prevent biofilm formation, and the equipment rinsed before work and between each patient. Flushing for

2 minutes in the morning and for 20–30 seconds between patients should be considered the norm for dental surgery procedures, and longer flushing is suggested after weekends (Williams *et al.,* 1993).
In the case of using storage tanks, they should be frequently washed and disinfected, filled with distilled sterile water at a temperature not exceeding 20°C. Periodical, adequately frequent monitoring of the water quality, including bacteria count and detection of Legionella species and Pseudomonas aeruginosa is necessary; this concern both the water supplied to hand pieces and the water used to flush a cuspidor and to rinse patients' mouth (O'Donnell *et al.,* 2011).
DCU reservoir bottles should be handled with care to minimize contamination with skin squames and should be cleaned and disinfected regularly.
Preferably, reservoir bottles should be regularly sterilized in an autoclave after thorough cleaning before refilling and re-use (O'Donnell *et al.*, 2011).
Antiretraction valves should be integrated into DCU-supplied instruments; Antiretraction valves may fail frequently resulting in retraction of oral fluids into DUWLs. Flushing DUWLs after each patient use is recommended (Williams *et al.*, 1993).
Uses of microbial filters at the ends of DUWLs near the instrument attachment sites or on DCU supply water lines, it can be effective in reducing microbial density in DUWL output water but has no effect on biofilm resident in DUWLs. Filters can be prone to clogging and have to be replaced regularly (Pankhurst and Coulter, 2007)
Draining or drying of DUWLs it has little effect on improving DUWL output water quality as biofilm resident in DUWLs can resist desiccation (Fiehn and Larsen, 2002).
Use of distilled water, deionized water, sterile water or pasteurized DUWL supply water provided from reservoir bottles, it has little effect on improving DUWL output water quality if biofilm is already resident in DUWLs. New DCUs may come with biofilms formed during factory quality testing (O'Donnell *et al.*, 2009).
Flushing of DUWLs with fresh water it results in reducing the microbial density in DUWL output water, but not to acceptable levels. It has no effect on DUWL biofilm (Pankhurst and Coulter, 2007; O'Donnell *et al.,* 2009).

Chemical Agents tested in DCUs

Chlorhexidine gluconate, chlorhexidine gluconate and alcohol, Activated chlorine dioxide, chlorine dioxide and sodium phosphate, Glutaraldehyde, glutaraldehyde and quaternary ammonium salts, Sodium hypochlorite and citric acid, Hydrogen peroxide, Hydrogen peroxide and silver, Alkaline peroxide, Electrochemically activated solutions, Peracetic acid, Povidone-iodine, Sodium fluoride, Sodium perborate, EDTA (O'Donnell *et al.*, 2011).
The use of chemical agents to control biofilm formation in DUWLs has potential for adverse effects on DCU components and instruments, on patient oral tissues and on dental restorative materials. This is particularly pertinent for residual treatment agents that are present in DUWL output water, which enter the patient's oral cavity and may also be swallowed or inhaled from aerosols generated by dental instruments.
Only a few studies of the long-term effectiveness of DUWL treatment agents have been reported to date and thus there is a dearth of independent information on potential adverse effects. A wide range of chemical disinfectants, biocides and cleaning agents used either periodically or continuously have been used to treat DUWL biofilm, with varying success.
Hydrogen peroxide-containing products and electrochemically activated solutions are among the most consistently effective (O'Donnell *et al.,* 2011).

Pretreatment of DCU Supply Water

A wide range of commercially available filters can be utilized for dealing with specific problematic aspects of DCU supply water quality including sediment filters (remove suspended solid contaminants), activated carbon filters (remove organic contaminants), water softening units for use in hard water areas and Kinetic Degradation Fluxion (KDF) filters that remove some dissolved metals (O'Donnell *et al.*, 2009).

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Conclusion

Insufficient awareness of health risk, working habits, and economic factors are the reasons why dentists do not apply the available and recommended methods of protection against the influence of dental aerosol. Behavior protecting a dentist and an assistant from the threat resulting from the influence of dental aerosol cannot be limited to isolated actions. Air-conditioning and ventilation systems should be regularly maintained to reduce environmental contaminants and to prevent recirculation of bacterial aerosols. Pre-procedural rinsing by patients with mouthwashes as well as vacuum and electrostatic extraction of aerosols during dental procedures could also be employed. Dental staff should also consider appropriate immunizations and continue to use personal protective measures, which reduce contact with dental aerosols dental practice.

REFERENCES

Abbott JN, Alonzo TB and Denaro SA (1955). Recovery of tubercle bacilli from mouth washings of tuberculous patients. *Journal of the American Dental Association* **50** 49–52.

Allsopp J, Basu MK, Browne RM, Burge PS and Matthews JB (1997). Survey of the use of personal protective equipment and prevalence of work related symptoms among dental staff. *Occupational and Environmental Medicine* **54**(2) 125- 34.

Azari MR, Ghadjari A, Massoudi Nejad MR and Nasiree NF (2008). Airborne Microbial Contamination of Dental Units. *Tanaffos* **7**(2) 54-57

Bednarsh HS, Eklund KJ and Mills S (1996). Check your dental unit water IQ. Dent Assist **65**(6) 9-10

Belting CM, Haberfelde GC and Juhl LK (1964). Spread of organisms from dental air rotor. *JADA* **68** 34-37

Bently CD, Burkhart NW and Crawford JJ (1994). Evaluating spatter and aerosol contamination during dental procedures. *Journal of the American Dental Association* **125** 579-584.

Berlutti F, Testarelli L, Vaia F, De Luca M and Dolci G (2003). Efficacy of anti-retraction devices in preventing bacterial contamination of dental unit water lines. *Journal of Dentistry* **31**(2) 105–100.

Centers for Disease Control and Prevention (2003). Guidelines for Infection Control in Dental Health-Care Settings, MMWR **52**(No. RR-17).

Davies KJ, Herbert AM, Westmoreland D and Bagg J (1994). Seroepidemiological study of respiratory virus infections among dental surgeons. *British Dental Journal* **176**(7) 262- 5.

Fiehn NE and Larsen T (2002). The effect of drying dental unit waterline biofilms on the bacterial load of dental unit water. *International Dental Journal* **52**(4) 251–254.

Finkbeiner BL and Claudia SJ (1995). *Comprehensive Dental Assisting: A Clinical Approach* (Mosby Year Book) St. Louis, Mo **159** 447–452.

Harrel SK and Molinari J (2004). Aerosols and splatter in dentistry: a brief review of the literature and infection control implications. *Journal of the American Dental Association* **135**(4) 429-37.

King TB, Muzzin KB, Berry CW and Anders LM (1997). The effectiveness of an aerosol reduction device for ultrasonic scalers. *Journal of Periodontology* **68**(1) 45- 9.

Legnani P, Checchi L, Pelliccioni GA and D'Achille C (1994). Atmospheric contamination during dental procedures. *Quintessence International* **25**(6) 435- 9.

Logothetis DD and Martinez-Welles JM (1995). Reducing bacterial aerosol contamination with a chlorhexidine gluconate pre-rinse. *Journal of the American Dental Association* **126**(12) 1634-9.

Merchant VA (1991). Herpesviruses and other microorganisms of concern in dentistry. *Dental Clinics of North America* **35**(2) 283-98.

Michel O, Kips J and Duchateau J *et al.*, (1996). Severity of asthma is related to endotoxin in house dust. *American Journal of Respiratory and Critical Care Medicine* **154**(6 Pt 1) 1641–1646.

Miller RL (1995). Characterstics of blood containgin aerosols generated by common powered dental instruments. *American Industrial Hygiene Association Journal* **56** 670-676.

Miller RL and Micik RE (1978). Air pollution and its control in the dental office. *Dental Clinics of North America* **22** 453-467.

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Muir KF, Ross PW, Macphee IT, Holbrook WP and Kowolik MJ (1978). Reduction of microbial contamination from ultrasonic scalers. *British Dental Journal* **145** 76–8.

O'Donnell MJ, Boyle M, Ronnie RJ and Coleman DC (2011). Management of dental unit waterline biofilms in the 21st century. *Future Microbiology* **6**(10) 1209–1226

O'Donnell MJ, Boyle M, Swan J, Russell RJ and Coleman DC (2009). A centralised, automated dental hospital water quality and biofilm management system using neutral Ecasol maintains dental unit waterline output at better than potable quality: a 2-year longitudinal study. *Journal of Dentistry* **37**(10) 748–762.

Panis B, Roumeliotou-Karayannis A, Papaevangelou G, Richardson SC and Mitsis F (1986). Hepatitis B virus infection in dentists and dental students in Greece. *Oral Surgery, Oral Medicine, Oral Pathology* **61**(4) 343-5.

Pankhurst CL and Coulter WA (2007). Do contaminated dental unit waterlines pose a risk of infection? *Journal of Dentistry* **35**(9) 712–720.

Putnins EE, Di Giovanni D and Bhullar AS (2001). Dental unit waterline contamination and its possible implications during periodontal surgery. *Journal of Periodontology* **72**(3) 393–400.

Reinthaler F, Mascher F and Stunzner D (1998). Serological examinations for antibodies against Legionella species in dental personnel. *Journal of Dental Research* **67** 942– 3.

Singh TS, Bello B, Mabe OD, Renton K and Jeebhay MF (2010). Workplace determinants of endotoxin exposure in dental healthcare facilities in South Africa. *Annals of Occupational Hygiene* **54**(3) 299–308.

Stephen K and Harrel SK (2004). Airborne Spread of Disease –The Implications for Dentistry. *CDA Journal* **32**(11).

Thomas DL, Gruninger SE, Siew C, Joy ED and Quinn TC (1996). Occupational risk of hepatitis C infections among general dentists and oral surgeons in North America. *American Journal of Medicine* **100**(1) 41- 5.

Toroglu MS, Bayramoglu O, Yarkin F and Abdullah T (2003). Possibility of Blood and Hepatitis B Contamination Through. Aerosols Generated During Debonding Procedures. *Angle Orthodontist* **73** 571–578.

Williams JF, Johnston AM, Johnson B, Huntington MK and Mackenzie CD (1993). Microbial contamination of dental unit waterlines: prevalence, intensity and microbiological characteristics. *Journal of the American Dental Association* **124**(10) 59–65.