Dental Unit Waterlines

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OSAP Symposium, June 13-15 2013

Disclosure

Neither I nor members of my immediate family have any financial relationships with commercial entities that may be relevant to this presentation.

Topics

1. Background
2. National Standards and Guidelines, Goals and Recommendations
3. Relationship between biofilm and DUWL contamination
4. Types of microorganisms recovered from DUWL
5. Scientific evidence of adverse health effects
6. Current approaches to improving DUWL quality
7. Rationale and strategies for monitoring DUWL quality

Background

1963
- First report of contaminated reservoir bottles
- 0.2% CHX diluted 1:10,000 reduced bacterial counts ≥3 mo.
  Blake GC. BDJ 1963

1976
- Report of contamination of HS handpiece, a/w syringe, ultrasonic lines 2-3 million CFU/mL
- 2-minute flushing reduced bacterial levels, not complete elimination
  Gross AG et al., J Periodontol 1976

1987
- Case reports of medically compromised patients infected with organisms originating from DUWL
  Martin MV. BDJ 1987

National Standards and Guidelines, Goals and Recommendations

1978 – ADA statement
- Flush DUWL with chemical germicides
- Deferred to dental unit manufacturers on methods

1993 – CDC recommended:
- Installation of and maintenance of antiretraction valves to limit retraction of contaminated fluid
- Flushing lines between patients (20-30 secs) and beginning of each day
- Sterile irrigants for surgical procedures

1996 – ADA Statement
- Manufacturers and researchers challenged to deliver patient treatment water of 200 CFU/mL by Y2000

CDC Guidelines for infection control in dental health-care settings - 2003
“Use water that meets *EPA regulatory standards for drinking water for routine dental treatment water output.”

*<500 colony-forming units per milliliter (CFU/ml) of drinking water

7 Dental Units and DUWL Tubing
- Polyurethane or polyvinyl chloride (PVC) DUWL tubing
- Hardeners and additives
- Nutritive source for microorganisms
- 1/16” or 2mm in diameter
- Non-flexible couplings (1/8 or 4mm in diameter)
  - Surface area to volume approx. 6:1
- Water flow rates 60-100mL/min
  - Infrequent
  - Stagnation

8 Biofilm

9 Biofilm Attachment
- Initially long-range weak reversible interactions
- Subsequent irreversible binding
- Efficient microbial community

10 Types of Microorganisms
- Some oral organisms
  - Backflow from patients to DUWLs
  - Organisms mainly derived from source water
  - Heterotrophic, mesophilic bacteria
    - Use organic carbon from another source for growth
    - Moderate temperature

11 Types of Microorganisms – cont’d
- Predominantly gr -ve species
  - Lipopolysaccharides (endotoxins) in cell wall
  - Inflammatory response in humans
  - Association between asthma & high levels of gr -ve species in indoor environment
  - Endotoxin levels as high as 15,000 EU/mL in DUWL
    - FDA recommended level for injection and irrigation fluids – 0.25EU/mL-1

12 Microorganisms of Concern
- Legionella
  - Pontiac fever, Legionnaire’s Disease
- Pseudomonas species
  - Lower respiratory infections
- Non-tuberculosis mycobacteria (NTM)
  - Resistant to chlorine, iodine
  - Biofilms important replication sites
  - Associated with outbreaks of hospital infections
  -
Dental Literature
- First case report described in 1987 (P. aeruginosa)
- Fatal case of legionella pneumonia in a dentist attributed to L. dumoffi
  - Evidence circumstantial
  - L. dumoffi and other Legionella spp. recovered from lung autopsy and from DUWL
  - None recovered from domestic water supply
  - Isolates not available for molecular typing
  - Fatal case of pneumonia (L. pneumophila) in 82-yr old Italian woman 2011
    - Ricci ML et al., 2012

Legal Cases
- 1990
  - Lawsuit filed against manufacturer due to absence of antiretraction valve on unit
    - Mills SE. 2000
- 1999
  - Patient claimed that brain abscess was the result of contaminated DUWL
    - Mills SE. 2000
- 2007
  - Patient claimed that chronic eye damage was result of contaminated DUWL
    - Barbeau J. 2007

Management and Treatment of DUWL contamination

Flushing
- NO EFFECT ON BIOFILM
- 5-7 minute flush required before microbial counts reduced to 200 CFU/mL
- Frequent clinical use will reduce bacterial counts in output water

Delivery Systems and Chemical Products
- Independent reservoirs
- Sterile water systems
- Filtration
- Water purifiers
- Hydrogen peroxide
- Chlorine dioxide
- Sodium hypochlorite
- Chlorhexidene
- Silver ions
- Iodine
- Ozone
- Peracetic acid
- Acidic electrolyzed water

Product EPA Registration
- Manufacturers submit their own efficacy data
- Products with germicidal claim
  - Must have specific EPA registration
- Marketed as cleaners without EPA number
  - Not disinfectants
**Chemical Products for Intermittent Use**

- Automated with built-in microprocessors
  - Removes personnel compliance issues
  - Limited data *Puttaiah R et al., 2012*
- Electrochemically-activated (ECA) solution
  - *In-vitro* research
  - Non-toxic to biological tissues *Zhang W et al., 2007*

**Other Approaches – cont’d**

- Centralized system for institutions
  - Filtration, purified, ECA before distribution to multiple chairs
  - No adverse cytotoxic or equipment effects
    *Coleman DC et al., 2009; Boyle et al., 2010*

- Sodium bicarbonate and other ingredients
  - *In vitro* testing showed degraded polysaccharide adhesions
    *Gawande PV et al., 2008*

**Other approaches – cont’d**

- Tubing surface modification
  - Interruption of microbial communication
  - Or decomposition of polysaccharides
- Active agents
  - Silver ions
  - Polyvinylidene fluoride
  - Polytetrafluoroethylene coating
  - *N*-halamines

**N-halamine DUWL Tubing**

- Rechargeable with chlorine
- Prevents biofilm formation

**N-halamine Research Findings and Clinical Significance**

- Control tubing (Red) correlated with Time
  - Due to biofilm formation
- Test tubing not correlated with Time
  - Due to absence of biofilm
- Recharge Control (Green) tubing correlated with Time and Source Water Level
  - Intermittent treatment products without biofilm controlling functions no advantage
- Test tubing and effluent (Blue) correlated with Source Water Levels
  - Patient treatment water reflects source water

**SEM images**

**Concerns about use of chemicals**

**Effect on Environment and Dental Materials**
Mobilization of mercury from amalgam particulate resulting in high levels of mercury in wastewater

Stone ME et al. 2006;
Batchu H et al., 2006

- Enamel and dentin bond strength
  - Strength-testing methods inconsistent
  - Results dependent on characteristics of adhesives used rather than DUWL cleaner

Von Fraunhofer JA et al., 2004
Ritter AV et al., 2007

Susceptibility of Organisms to Disinfectants

- Innate resistance of NTM and others

Porteous NB et al., 2004
- Opportunistic organisms in absence of competing organisms

Porteous NB et al., 2003;
CDC. Guidelines for Disinfection and Sterilization in Healthcare facilities, 2008

Dental Units

- Incompatibility of products with units
  Puttaiah R et al., 2012
- Clogging of lines
  O’Donnell MJ et al., 2009
- Corrosion of metal parts
  Coleman DC et al., 2009

Which product do I choose?

- Know your system requirements
- FDA clearance for medical devices
- EPA registration for product germicidal claim
- Scientific literature for efficacy
  - articles on product testing
  - H₂O₂; ClO₂; NaOCl; CHX; others
- Check with manufacturers for equipment compatibility
- Monitor regularly

How to Monitor Water Quality

-
In-office chairside testing
- Laboratory testing

**Chairside Testing Kit**
- HPC Total Count Sampler
  - (product id MHPC10025)
    - Millipore
    - Tel: (800) 645-5476
- Petrifilm™ plates
  - 3M Products
  - Tel: (888) 364–3577

**Advantages/Disadvantages of Chairside Monitoring**
- Convenient
- Easy-to-use
- Underestimation of counts
- Certain phenotypes fail to grow
- Screening tool
- Correct by factor of 1.5

**Commercial Laboratory Testing**
- MicroTest Laboratories
  - email: microtestlabsinc@yahoo.com
  - Phone: 1-916-567-9808
- IDEXX Laboratories Inc.
  - SimPlate® for HPC
  - Phone: 1-800-548-6733
- ProEdge Dental Products
  - Phone: 1-303.962.8820

**Commercial Laboratory Testing cont’d**
Loma Linda University School of Dentistry
- email: SAS@llu.edu
- Phone: (909) 558-0656
- The Texas A&M University System Health Science Center Baylor College of Dentistry
  - email: cdms@tambcd.edu
  - Phone: (214) 828-8446
- University of Tennessee Health Science Center College of Dentistry
  - email: utomds@utmem.edu
  - Phone: (901) 448-5876

**Interpreting Results**
- Variables affecting bacterial counts
  - Sampling method
  - Time
Comparison of two Laboratory Methods

Summary

Useful Web Links

- www.osap.org
- http://www.ada.org/sections/professionalResources/pdfs/art_cleaning_waterlines.pdf

Thank you for your attention!