Dental Treatment Water Contamination, Control, and Monitoring
Prof. Raghunath Puttaiah, Texas A&M University, Baylor College of Dentistry
A Webber Training Teleclass

DENTAL TREATMENT WATER CONTAMINATION, CONTROL AND MONITORING
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Contamination Levels in Dental Treatment Water
• Tap/Municipal Water has 40 – 400 CFU/mL
• Dental TX Water has heterotrophic counts in excess of 1,000,000 cfu/mL
• Mature biofilms develop in the within a period of 4 weeks
• Microorganisms found in this biofilm could be pathogenic in such high doses
• There is a potential for infection and disease

Types of Contaminants
• Inorganic salts (cations, anions)
• Bacteria, viruses, fungi
• One source human waste treatments

Where did these water samples come from?

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- Salts from municipal water affect repulsive charges of the line against bacterial settlement.
- Also cause tarnish, corrosion and blockage of the system.
- Glycocalyx, macromolecules & bacteria adhere to the inner lumen.
- Planktonic organisms (free-floating) adhere to these molecular insertions.
- Form layers and a mature matrix in weeks with intricate lattice-work.
- Thickness of biofilm 30-100 microns.
- Chunks break up contaminating water.

Salts in the municipal water
1. Distiller still with heating element
2. Still with salts after distilling about 450 gallons of municipal water
3. About 450 gallons of municipal water in Dallas, showed about 300 grams of salts.

Biofilm formation
This is how a biofilm looks in the dental unit waterlines

-> Weeks 3, 8, 10, 26, >10 years

Evidence of disease risk
- Fitos et al; JDR 1985, 64(12):1382 - 1385.
  20% of students & employees in dental settings showed higher IgG antibodies to Legionella than Controls.
  High prevalence (50%) of antibodies to Legionella in dentists.
- Oppenheim et al; Epidemiol & Infect 1987, 99:159-166.
  Aerosols from dental units found to be the source of sub-clinical infection with L. pneumophila in a dental school.
  68% of DUW samples from 28 dental clinics had Legionella.
  41% of potable water from domestic/institutional faucets had at least one form of Legionella.

But we waited for dead bodies..

Possible high risk patients:
- Neutropenic Patients
- Post Radiotherapy
- Uncontrolled Diabetes
- Spina Bifida
- Patients with certain Cancers
- Patients with other Chronic Illnesses
- Chronic nutritional deficiencies

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Legionnaire’s Disease & Pontiac Fever
- 1976, Philadelphia, Veterans of the American Legion Meet. 182 Cases of pneumonia and 29 deaths
- 1977 Causative microorganism identified and duly named Legionella pneumophila
- Two Clinical Conditions —Legionnaires’ disease & Pontiac Fever
  - Signs & Symptoms of Legionnaires’ disease—Fever, chills, cough, muscle aches, headache, weakness, loss of appetite, nausea, diarrhea, vomiting, relative bradycardia in spite of fever. Impaired Renal Function, Liver Function, Electrolyte Imbalance and Hyponatremia. X-rays show pneumonia
  - Incubation period 2-10 days after exposure
  - Difficult to differentiate from other pneumonias or influenza based on clinical findings alone
  - Signs and Symptoms of Pontiac Fever—Fever and muscle aches without pneumonia with recovery in <5 days without anyTx
  - Incubation period is a few hours to 2 days after exposure
  - Both conditions are common in the old, smokers and immunocompromised people

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Death due to Legionella pneumophila infection from dental unit water system
- Legionnaires’ disease was promptly diagnosed by Legionella pneumophila urinary antigen test and bronchial aspirate for microbiological examination
- Patient developed fulminant and irreversible septic shock and died 2 days later
- Investigation to find the source of L pneumophila infection revealed Dental Clinic Water Samples showed positive for L. pneumophila (6.2X10⁴ CFU/mL)

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Death due to Legionella pneumophila infection from dental unit water system
- Italy: February, 2011, an 82-year-old woman admitted to hospital due to fever and respiratory distress
- Radiography showed several areas of lung consolidation

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Reference:
Pneumonia associated with a dental unit waterline. Maria Luisa Ricci, Stefano Fontana, Federica Pinci, Emanuela Fiumana, Maria Federica Pedna, Paolo Farolfi, Maria Antonietta Bucci Sabattini, Maria Scaturro. Lancet 2012; 379: 684

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Factors associated with contamination
- Long periods of stagnation
  - Cumulative use per day ≥ 2 hours
  - Overnight stagnation > 12 hours
- Nutrient content of source water for microbial survival
- Minerals
  - Organic matter
  - Mineral content & hardness of water assist in coating of lines

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High Surface to volume ratio: Smaller the diameter of line, more relative surface available per volume of water & vice-versa

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Histopathology Slide

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Endotoxins & Disinfection-by-products
- *Bacteria die, endotoxins are released and have a potential for a pyrogenic response (inflammation)
  - Amounts of endotoxins found in tap water ranges from 10 to 20 EU/mL
  - The first flush with water after cleaning lines with a Hypochlorite shows >500 EU/mL
  - Constantly present bleach (1.5-5 ppm) in lines with biofilms shows about 30-100 EU/mL
- AAMI standards for Renal Dialysate <5 EU/mL

Low flow rate
- Fluid dynamics (laminar flow)
  - Lesser resistance in the center of the lumen therefore biofilm not disrupted by flushing
- Microbial quality of source water

Endotoxins & DBPs
- Occur in water due to the action of NaOCl on biofilms (organic)
- EPA’s exposure limits <100 ppb
- Proposed EPA exposure limit <80 ppb
- DUWL with mature biofilms when cleaned with 5000 ppm bleach show >8000 ppb
- In the presence of mature biofilms if 3-4 ppm bleach is used, we can get in excess of 5000 ppb of THM
- THMs are suspected carcinogens
- Therefore, use of bleach is questioned

*Puttaiah et al, IADR 1999, Abstract – measurements of disinfection-by-products when bleach is used to clean water treatment dental water systems
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Evaluation of TAED Perborate Simulating the Castellini Autosteril System

- 4 Dental Unit Water Systems
  - G1 = TAED cleaning between simulated patients + use of Sterile water
  - G2 = TAED cleaning between simulated patients + use of 2ppm ClO2 in tap water
  - G3 = TAED cleaning between simulated patients + use of tap water
  - G4 = No periodic cleaning or chemical regimen + use of tap water only

Results – heterotrophic plate counts

<table>
<thead>
<tr>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>0.1</td>
<td>0.1</td>
<td>1.2</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Control Group significantly more contaminated than treatment groups (p < 0.05)
All treatment samples achieved the ADA's goal of <200 cfu/mL

Microbiological Monitoring by Comprehensive Monitoring Services, Baylor College of Dentistry

Results – Biofilm Control Scanning Laser Confocal Microscopy

Red stain = dead microorganisms; Green stain = live microorganisms; Magnification 100X
Biofilm remains observed in all treatment samples at the end of the study. Biofilm present in control sample.

Results – Biofilm Control Scanning Electron Microscopy

Accelerated corrosion tests: 2 months in TAED @ 56o Celsius
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Conclusion

• Reduces workload for employees
• Removes Biofilms
• Colony counts almost ZERO
• Chemical very compatible with the Autosteril System
• Exceeds CDC’s and ADA’s requirements
• May be a good alternative in areas where the US regulations are not applicable for Surgical Water/Application

Some items in the US & Other Markets
• Registration of the chemicals with agencies such as the United States Environmental Protection Agency (US-EPA) and clearance of the United States Food and Drug Administration (US-FDA) or agencies in the European Union (EU) for safety issues or with Regulatory Agencies in India
• Biofilms and other deposit removal efficacy
• Proven Compatibility with metals, plastics and rubbers in the water system
• Proven evidence of easy removal of periodic cleaning agent from the water system
• Biocompatibility of periodic cleaning agent and irrigant with humans
• Should not produce dangerous disinfection-by-products such as trihalomethanes
• Proven compatibility of irrigant with composites bonding to enamel and dentin

Some methods of microbial control

• Physical Methods
  1. Single-patient-use (0.22 micron) with endotoxin retention capability
  2. Daily change Point-of-use (0.22 micron) filters
  3. Weekly change point-of-use (0.22 micron) filters
  4. Weekly change point-of-use filter cartridges with iodinated resin

Some items in the US & Other Markets

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Cleaning Lines – One Method

Monitoring of Microbial Quality

Screening Vs. Diagnostic tests
1. HPC Water Samplers (Millipore Inc.)
2. Aquasafe Samplers (Pal Corp.)
3. R2A Agar is the Gold Standard
   The error rate of HPC samplers was ~40%. When compared to R2A (Puttaiah, et al., AADR 2002; Abstract J08)
   Significant decrease in detection by HPC and Aquasafe in comparison to R2A (Puttaiah, et al., AADR 2002; Abstract J08)

Goals & Standards ??

- The American Dental Association stated in 1995 that its Goals for year 2000 was that the dental treatment water to be <200 CFU/mL of heterotrophic mesophilic organisms.*
- What are the reasons the ADA and the BDA have given for not making it a recommendation
  - No mortality associated with the high levels of microbial contamination?
  - Do we wait for mortality and morbidity to drive all policies???
  - Do the microorganisms found in dental unit water systems have the potential for causing infections and death among dental patients?
  - What categories of dental patients do we have based on susceptibility for infection and death?
- Current CDC’s recommendation is <500 cfu/mL

Corrosive Nature of Irrigants

Irrigant Compatibility with Bonding

BioClear
- Cle SYS II
- Oris CHX
- Tap water
- Bio 2000
- DioxClear™
- Dentagure

No significant difference between bond strength between TEs, alpha=0.05.
Puttaiah, Griggs et al., in preparation. Other studies have shown varying degrees of effects but no control of bias and binding.

Coming Soon

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