Investigating the Efficacy and Safety of Silver Nanoparticles in Treating Oral Bacterial Biofilms

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Introduction

- 47% experience periodontal disease, 70% over 65
- High sugar diets and an aging population
- Bacterial biofilms
- Novel methods for treatment (Silver nanoparticles)

*Figure 1: Presence of bacterial biofilms on the teeth surface (European Federation of Periodontology, 2016)*
Periodontal Disease

- Tooth and gum decay from bacterial biofilms
- *Streptococcus mutans* and *candida albicans*
- Progresses over time
- More cases per year

*Figure 2: Healthy tooth vs. tooth with periodontal disease*
Candida albicans

- Fungal bacteria
- Harbored on skin and mucous membranes
- Feeds on food in mouth

**Figure 3:** C. albicans as seen by a microscope

**Figure 4:** C. albicans accumulation on the tongue
Streptococcus mutans

- Spherical (coccus) bacterium
- Uses sucrose to build capsule
- Sticks tightly to tooth
- Cause of cavities

Figure 5: S. mutans at the microscopic level showing coccus structure (Encyclopedia Britannica)
Aging Population

- Total fertility rate of 1.84 in 2015
- Replacement level is 2.1
- Maturing population
- Periodontal disease more common among older adults

*Figure 6: Maturing population of the United States (Census Bureau, 2016)*
Figure 7: Instances of periodontal disease across age group subsets (CDC, 2010)
Chlorhexidine Solution

- Most common current treatment
- Common disinfectant
- Biguanide compound
- Positive charge attaches to cell membrane leading to organelle leakage

Figure 8: Molecular structure of chlorhexidine solution (NIH, 2018)
Search for More Effective Treatment

- Increased rate of periodontal disease
- Greater medical cost
- Research into new methods of killing and inhibiting the bacteria

Figure 9: Chlorhexidine solution being injected into gums (Indian Society of Periodontology, 2013)
Silver in Medicine

- Used for over 6,000 years
- Symbol of health and prosperity
- Colloidal silver in 19th century
- Silver in preventing microbial infections (bandaging, equipment)

*Figure 10: Early use of silver for food storage (Indian Express, 2017)*
Silver Nanoparticles

- Found effective against many oral bacteria
- Tested *in vitro*
- Varying sizes
- Incorporated into larger applications (dentures)

*Figure 10:* Silver nanoparticles seen at different magnitudes using transmission electron microscopy (Oldenburg, 2010)
Controversy

- Concern whether harmful to mouth
- Study showed toxicity to human and rat embryonic neural stem cells (Lui et al., 2015)
- Cells unable to reproduce; died
Purpose

Determine whether silver nanoparticles are an effective method of treating *S. mutans* and *C. albicans* bacterial biofilms while avoiding causing harm to human cells over time.
Research Question

Are silver nanoparticles an effective and safe method of treatment for *S. mutans* and *C. albicans* biofilms over time?
Hypothesis

Silver nanoparticles can provide effective treatment of *C. albicans* and *S. mutans* biofilms while causing negligible damage to human cells.

Null

Silver nanoparticles cannot provide effective treatment of *C. albicans* and *S. mutans* biofilms while causing negligible damage to human cells.
Methods

- Systematic literature review from data sources 2005-present
- Information collected on oral and dental applications of silver nanoparticles, toxicity experiments, bactericidal testing against oral bacteria, reports of issues with usage
- Focused summary of findings
Sources and Keywords

- Online databases: EBSCOhost, Google Scholar, Public Library of Science, ScienceDirect
- Keywords for article searches included: silver nanoparticles, efficacy, safety, applications, toxicity, human, *S. mutans*, *C. albicans*, biofilms, denture, denture base liner, and chlorhexidine
Results

**Figure 11:** In vitro testing of silver nanoparticles against *C. albicans*. Evaluated by silver nanoparticle concentration (*p*=0.000122).
Results

**Figure 11**: Clinical testing of silver nanoparticles in tissue conditioner against *S. mutans*. Evaluated by mass percentage and duration of use.
Results

**Figure 11:** Clinical testing of silver nanoparticles in tissue conditioner against *C. albicans*. Evaluated by mass percentage and duration of use.
Results

- In all clinical testing, no noticeable damage was caused to participants
- Up to seven weeks, issues were checked for
Sources of Error

- Fewer sources were evaluated than could be in a meta-analysis
- Clinical testing influenced by outside factors
Sources of Error

● Fewer sources were evaluated than could be in a meta-analysis
● Clinical testing influenced by outside factors
Discussion

- Exhibit increased efficacy with increased concentration
- Effectively kill *S. mutans* and *C. albicans*
- Clinical and *in vitro* tests similar
Discussion

● Silver nanoparticle-infused denture more effective against *S. mutans*
● Denture did no harm to patients across studies
● Concentrations similar at 24 and 72 hrs
● Efficacy maintained

*Figure 11: Upper and lower denture, upper infused with silver nanoparticles (Abdallah et al., 2015)*
Conclusion

- Silver nanoparticles are effective
- Efficacy doesn’t decline over time
- Safe when infused into dentures and presumably other appliances
Further Work

- Extended time experimentation in mouth
- Comparison to other nanomaterials
- Clinical testing of silver nanoparticles applied alone and not part of an appliance
Acknowledgements

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References


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