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

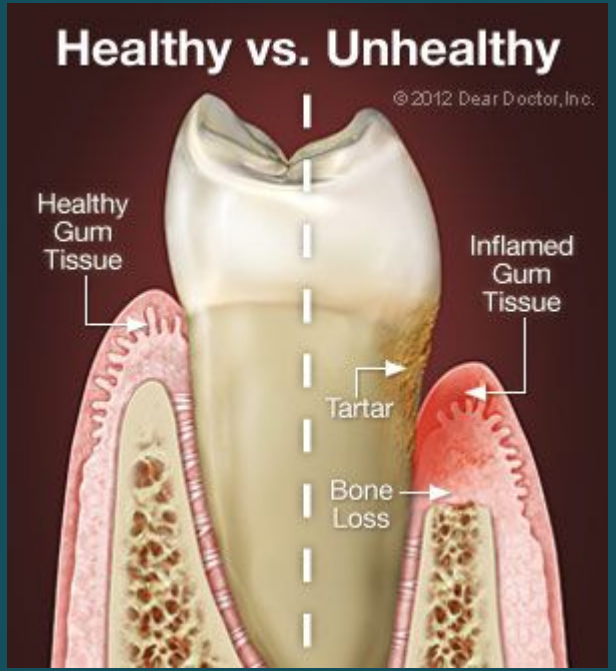


Figure 2: *Healthy tooth vs. tooth with periodontal disease*

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

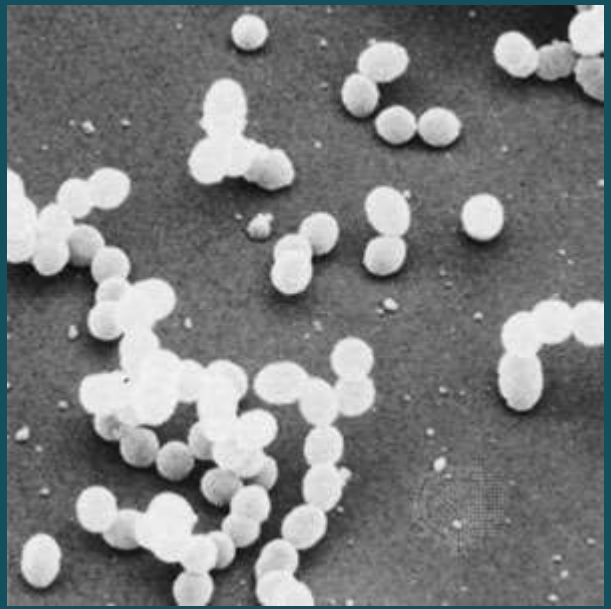


Figure 5: *S. mutans at the microscopic level showing coccus structure (Encyclopedia Britannica)*

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

Aging Population

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

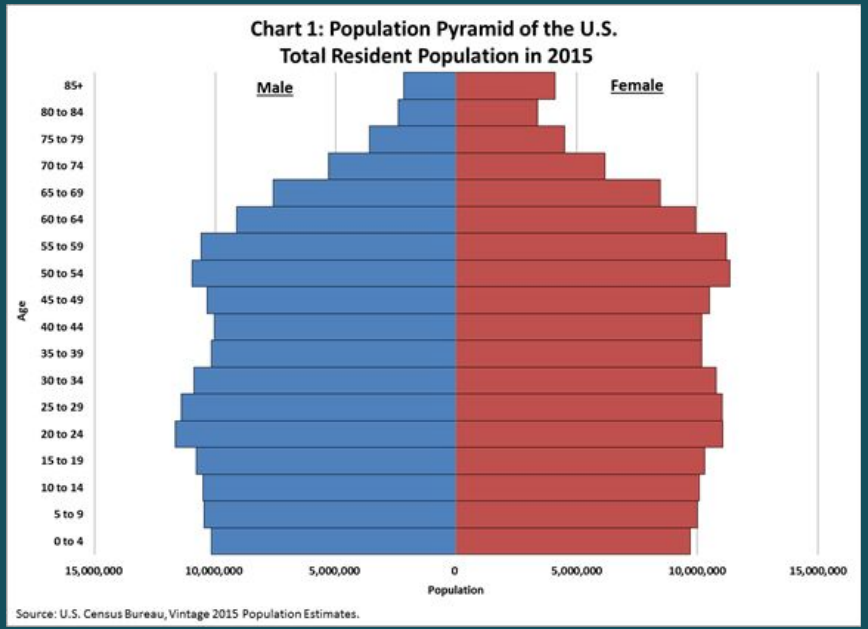
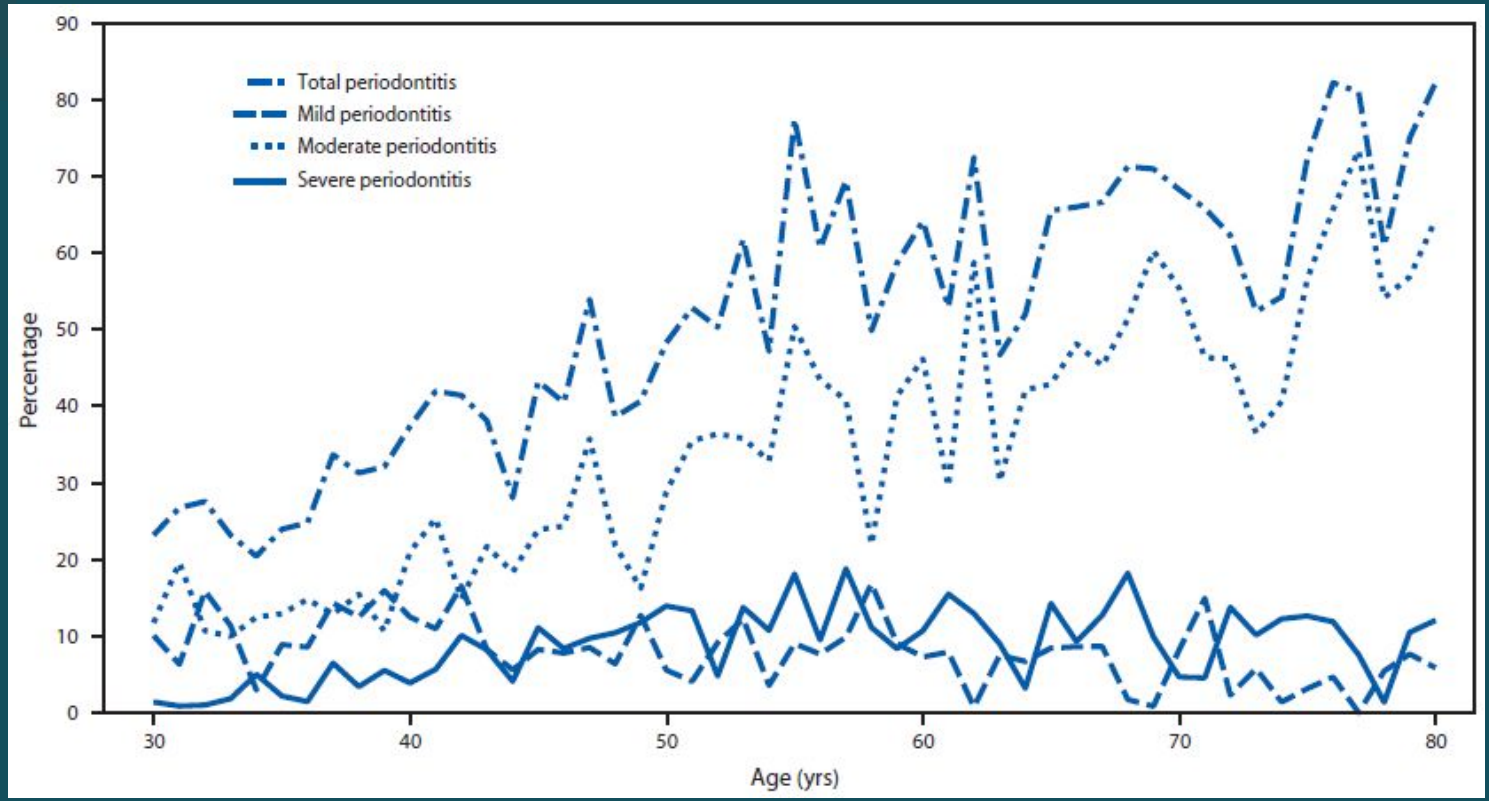


Figure 6: *Maturing population of the United States (Census Bureau, 2016)*

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

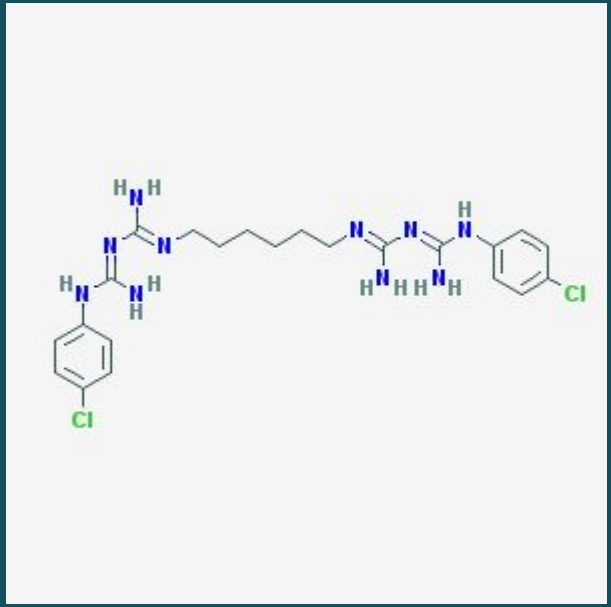


Figure 8: *Molecular structure of chlorhexidine solution (NIH, 2018)*

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)

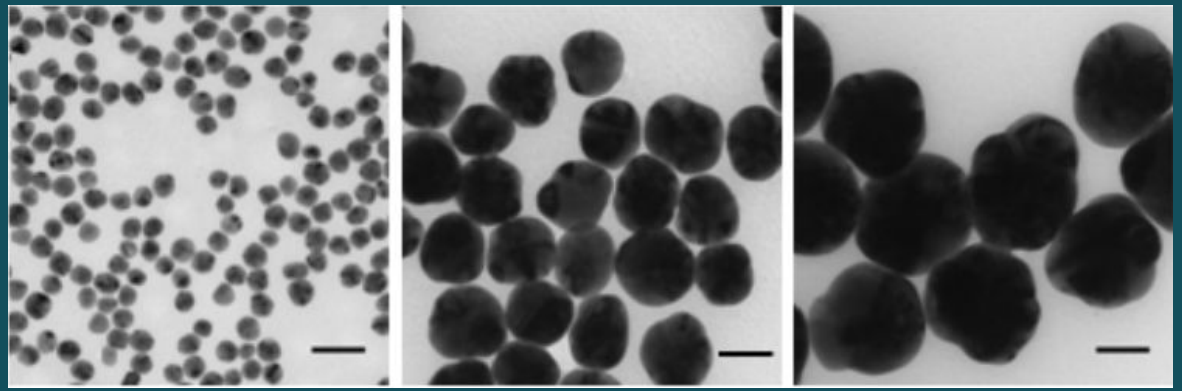


Figure 10: *Silver nanoparticles seen at different magnitudes using transmission electron microscopy (Oldenburg, 2010)*

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

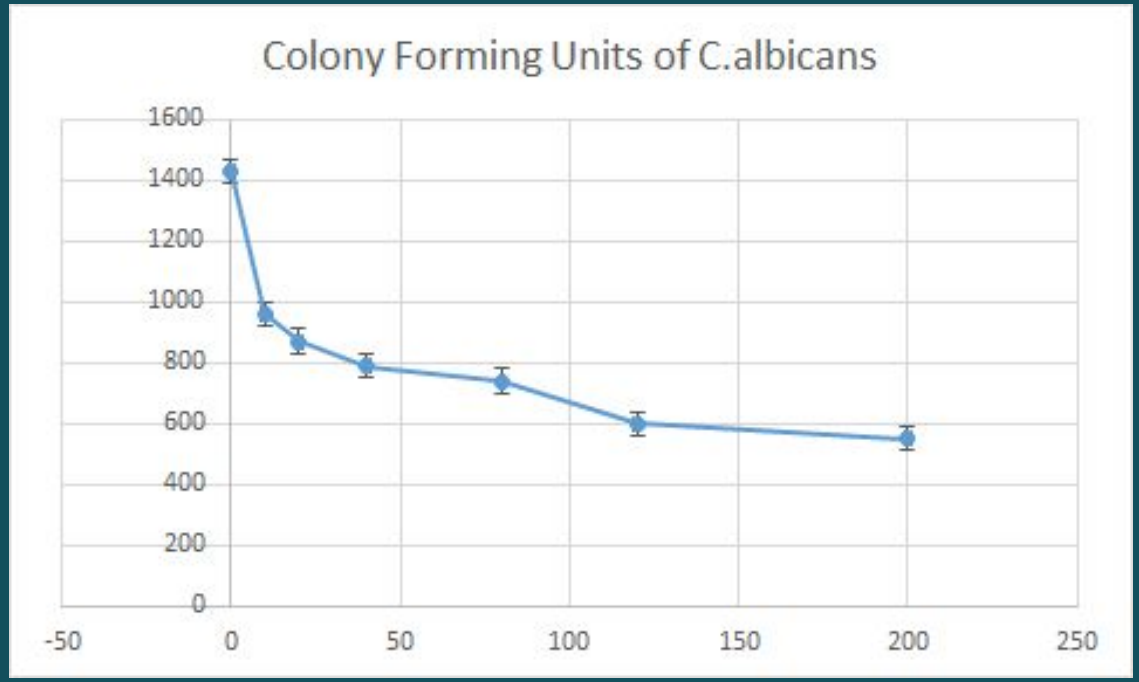


Figure 11: *In vitro testing of silver nanoparticles against C. albicans. Evaluated by silver nanoparticle concentration (p=0.000122).*

Results

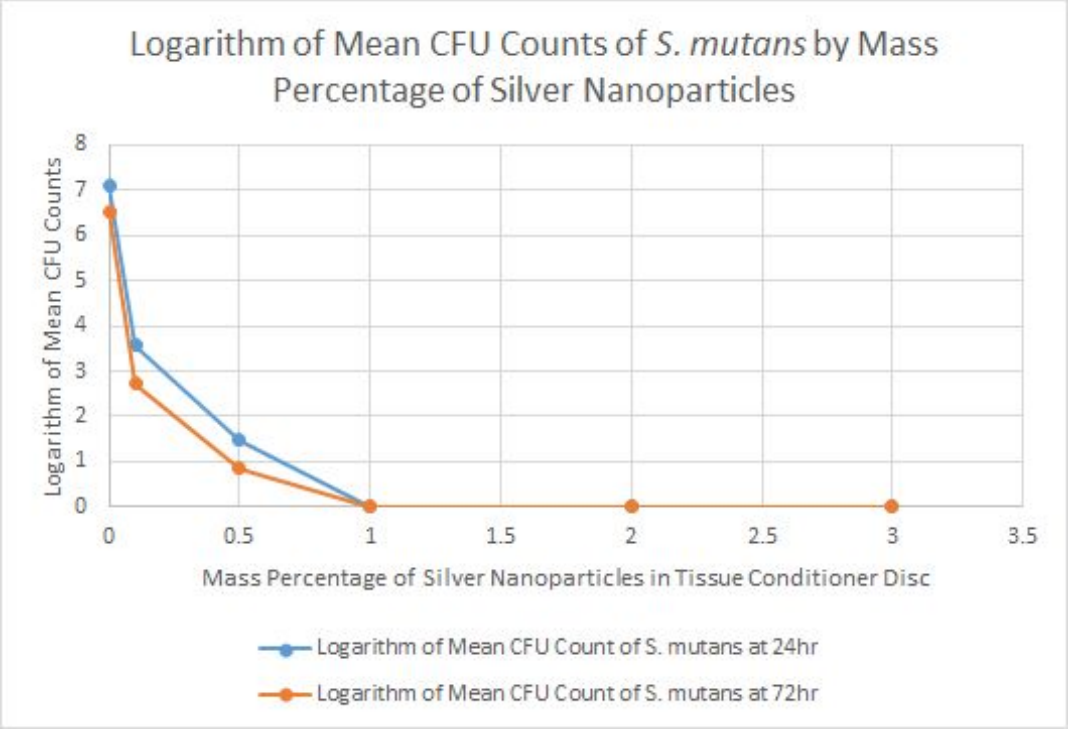


Figure 11: *Clinical testing of silver nanoparticles in tissue conditioner against S. mutans. Evaluated by mass percentage and duration of use.*

Results

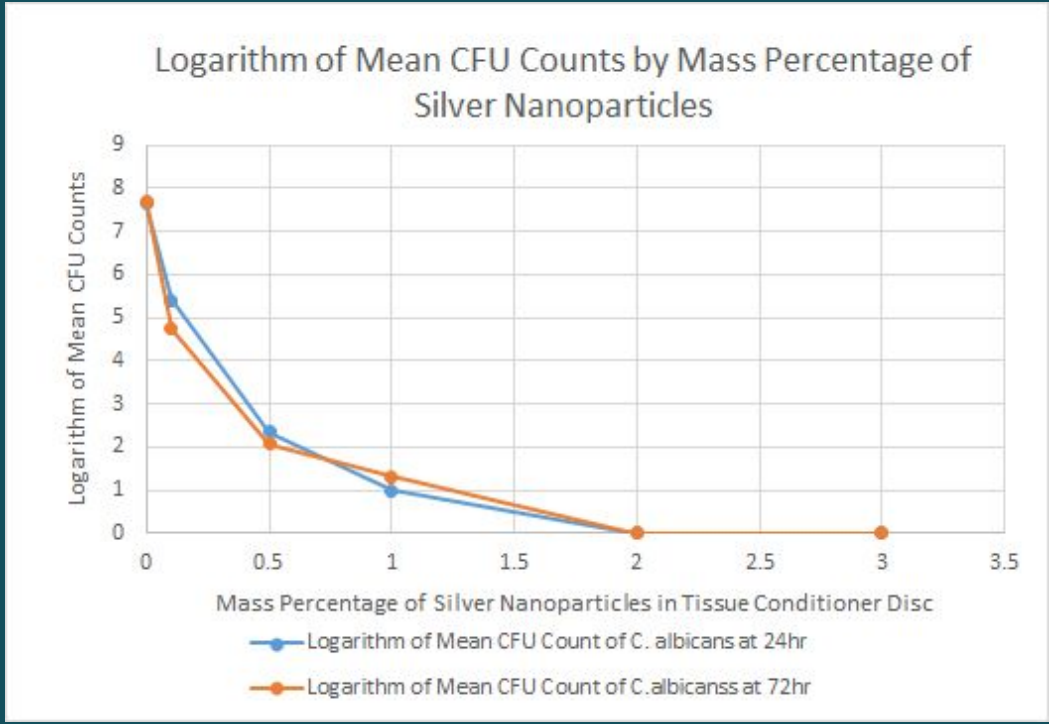


Figure 11: *Clinical testing of silver nanoparticles in tissue conditioner against C. albicans. Evaluated by mass percentage and duration of use.*

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

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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

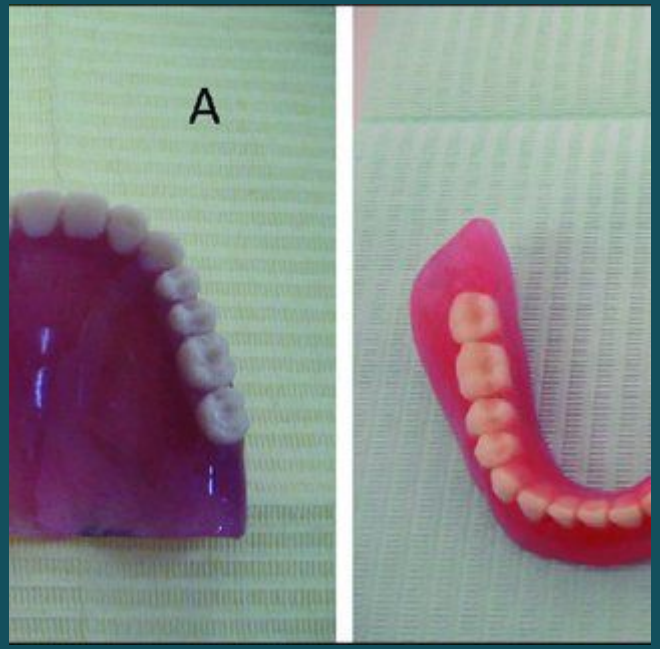

Figure 11: *Upper and lower denture, upper infused with silver nanoparticles (Abdallah et al., 2015)*

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

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