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Antimicrobial Efficacy of Chlorhexidine-Loaded Silver Nanoparticles on Enterococcus Faecalis Biofilm

(An In-Vitro Study)

Thesis

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By

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Dedication

All Love and respect to my great parents, you gave me the best of you and I hope to return even a fraction of what I received. I've come this far with your unconditional love and support my Role Models, my Life.

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List of Abbreviations

Abbreviation	Full Term
%R	Percentile Red Intensity per Slide
$C_{r\%}$	Percentage Reduction of log CFU
Ag^{+}	Silver ions
Ag-GO	AgNPs in aqueous Graphene Oxide matrix
Ag-MSNs@CHX	CHX-loaded, Silver-decorated Mesoporous Silica Nanoparticles
AgNPs	Silver Nanoparticles
AO	Acridine Orange
BHI	Brain Heart Infusion
BL	Buccolingual
CBD	Calgary Biofilm Device
CFU	Colony Forming Units
CHX	Chlorhexidine
CI	Conventional Irrigation
CLSM	Confocal Laser Scanning Microscopy
DL	Diode Laser
eDNA	Extracellular DNA

EDTA	Ethylene-Diamine-Tetraacetic Acid
EPS	Extracellular Polymeric Substance
HBD3	Human Beta-Defensin 3
HEDP	1-Hydroxyethane 1,1-Diphosphonic Acid
HMP	Human Microbiome Project
HUVECs	Human Umbilical Vein Endothelial Cells
ICG	Indocyanine Green
LPS	Lipopolysaccharides
LTA	Lipoteichoic acid
MBEC	Minimum Biofilm Eradication Concentration
MBIC	Minimum Biofilm Inhibitory Concentration
MD	Mesiodistal
MDR	Multiple Drug Resistance
MIC	Minimum Inhibitory Concentration
NaOCl	Sodium Hypochlorite
NIH-3T3	Mouse Embryonic Fibroblasts
NPs	Nanoparticles
NSG	Nanosilver gel
PC Im-based AgNPs	Positively-Charged Imidazolium-based Silver Nanoparticles

PCR	Polymerase Chain Reaction
PDT	Photodynamic Therapy
PI	Propidium Iodide
PLLA	Poly L-lactide
ppm	Parts per Million
PVP	Polyvinyl-pyrrolidone
qRT-PCR	Quantitative Real-time PCR
RC	Root Canal
RCT	Root Canal Treatment
ROS	Reactive Oxygen Species
rRNA	ribosomal RNA
SCHNC	Silver Cross-linked Hydrogel Nanocomposite
SD	Standard Deviation
SEM	Scanning Electron Microscope
TEM	Transmission Electron Microscope(y)
UAI	Ultrasonically-activated Irrigation
UV-Vis	Ultraviolet-visible
VBNC	Viable but Non-Cultivable
XPEF	XP Endo Finisher activation

Introduction

Microbial etiology is the leading cause behind almost all clinical endodontic pathosis. Bacteria, viruses, fungi and archaea contribute to the endodontic microbiota and biofilm formation; which may subsequently lead to primary or secondary infections of the root canal system, with or without periapical or periodontal involvement. These infections may persist long after standard endodontic treatment protocols application. Commonly isolated endodontic microbiota includes *Fusobacterium*, *Prevotella*, *Treponema*, *Actinomyces*, *Streptococcus*, etc; among which *Enterococcus faecalis* is the most commonly isolated endodontic pathogen. *E faecalis* can exist in primary and secondary infections, as well as in acute and chronic ones, in planktonic and biofilm phases, and in single-, dual- and multi-species biofilm.

Biofilms are the most predominant form of microbial existence in natural environment, on surfaces, and within infected tissues. Microbial biofilm is defined as an assemblage of surface-associated microbial cells (i.e. sessile cells) that are enclosed in an extracellular polymeric substance matrix (EPS). Microbial biofilms are structurally and metabolically heterogeneous, multicellular communities, where aerobes and anaerobes coexist. They grow slowly via a predictable arcade of events starting with microbiota attachment to a suitable substrate followed by its adhesion and EPS production, the biofilm then slowly