Characterization of a Novel Method for the in situ Deposition of Silver Nanoparticles on 3D-Printed Polylactic Acid to Synthesize an Anti-Bacterial Implant Material

Brahmbhatt, Isha (School: Ardsley High School)
Popova, Anastasia (School: Hackley School)

Bone implants are supporting structures in the body commonly used to treat fractures. Their integrity is threatened by bacterial biofilms that trigger an inflammatory response, loosening the implant and preventing it from providing the needed support. Silver nanoparticles (AgNP) have known antibacterial properties that may inhibit biofilm formation. Polylactic acid (PLA), is a biodegradable polymer that is FDA-approved for use in medical devices, and is more osseointegrable than currently used titanium dioxide. In this study, we are proposing a novel method for the in situ deposition of AgNP by reducing silver nitrate with sodium borohydride on softened PLA scaffolds. PLA scaffolds were printed using two different 3D printers with corresponding filaments, and AgNP of two concentrations were deposited. The mechanical / chemical properties (surface topography, surface chemistry, melting point) of PLA were retained by AgNP deposition. Dental Pulp Stem cells (DPSC) were plated on PLA-AgNP scaffolds to assess any cytotoxic effect of AgNP. DPSC morphology and proliferation was retained by AgNP deposition ($p > 0.05$). Staphylococcus aureus and Escherichia coli bacteria were plated on PLA-AgNP scaffolds to evaluate efficacy for biofilm inhibition. The 0.1M PLA-AgNP scaffolds had greater dead/live bacteria ratios as compared to 0.01M PLA-AgNP scaffolds. Biofilm inhibition was greater for E. coli, suggesting a higher efficacy on gram-negative bacteria. Significant increases in dead/live bacteria ratios ($p < 0.05$) suggest that PLA-AgNP scaffolds are promising antibacterial implant materials that can also be cost-efficient and be increasingly customizable per patient due to 3D printing capabilities of PLA.