Development of Stereolithography (SLA) 3D Printed Bone Cement Beads for Localized Antibiotic Delivery

Duncan Van Nest, Vivek Koratkar Bilolikar, James S Raphael[1], Solomon Samuel
[1]Albert Einstein Med Ctr

INTRODUCTION:

Polymethylmethacrylate (PMMA) antibiotic beads are widely used in orthopedic surgery for local antibiotic delivery to treat infections. However, the elution profiles of these beads can be inconsistent, leading to suboptimal local antibiotic delivery and manual, intraoperative production can lead to increased operative time and potential occupational hazard. 3D printing technology with resin polymer offers a promising solution by enabling the fabrication of antibiotic-eluting beads with controlled microarchitectures, potentially allowing for more effective elution profiles. This study aims to evaluate the feasibility of modifying in vitro elution profiles of antibiotics from 3D-printed resin polymer specimens and assess their antibacterial properties.

METHODS:

Antibiotic-eluting cylindrical specimens were 3D printed using a biocompatible clear resin mixed with either 2% vancomycin or tetracycline. Four drug loaded cylinders with distinct internal structures were evaluated: solid, hollow, large honeycomb, and small honeycomb. Only hollow cylinders were used to assess the differences in elution between vancomycin and tetracycline-loaded specimens. Elution profiles were assessed in vitro over 7 days by measuring the amount of drug eluted using a UV spectrophotometer at 281 nm. Agar diffusion assay was conducted against Staphylococcus epidermis to confirm that the antimicrobial effect was retained during the 3D printing process.

RESULTS:

Tetracycline-loaded cylinders exhibited a higher cumulative release compared to vancomycin-loaded cylinders, potentially attributable to differences in molecular weight and solubility. Among the designs tested, the honeycomb structures demonstrated the highest and prolonged elution profile. Both vancomycin and tetracycline-loaded cylinders exhibited large zones of inhibition against staphylococcus epidermis, confirming their antibacterial efficacy.

DISCUSSION AND CONCLUSION:

The findings of this in vitro study demonstrate the potential of 3D printing resin-based technology to fabricate antibiotic-eluting beads with customizable and predictable elution profiles. The honeycomb structures exhibited promising release kinetics, suggesting their potential suitability for orthopedic applications where sustained drug delivery is crucial. The differences in elution profiles between vancomycin and tetracycline underscore the importance of considering the molecular properties of drug when designing 3D-printed drug delivery systems. These findings highlight the promising role of 3D printing technology in developing next-generation antibiotic-eluting implants with tailored release kinetics. Future in vivo studies are warranted to validate these findings in a clinical setting.

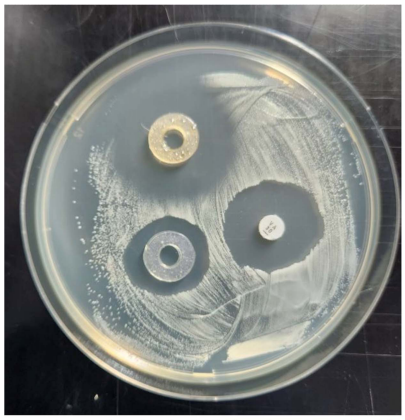

Figure 1: agar plate showing inhibition of s. epidermidis with vancomycin, tetracycline resin sample compared to tetracycline control