

Implant Materials Affect Biofilm Formation

David Kerr, Megan Zheng, Mark Wu¹, Jeffrey A O'Donnell, Daniel Ehren Goltz², Niall Hayward Cochrane³, Christine J Wu, Thorsten M Seyler⁴

¹Duke University Hospital, ²Duke University, ³Duke University Medical Center, ⁴Duke University School of Medicine

INTRODUCTION:

Bacterial surgical-site infections are a significant cause of morbidity and mortality globally, and lead to additional medical and surgical treatments, increased costs, and worse outcomes for orthopaedic patients. Bacteria forming extracellular biofilms are particularly resistant to antibiotic and surgical treatments when surgical implants are present. We compared the ability of staphylococcus aureus to form biofilms on common surgical implant materials.

METHODS:

Test coupons composed of hand-polished stainless steel (HPSS), titanium (Ti), titanium alloy Ti6Al4V (TiAlV), cobalt chrome alloy Co28Cr6Mo F1537 (CoCr), hydroxyapatite (HA), ultra-high molecular weight polyethylene (UHMWPE), polyether ether ketone (PEEK), and poly(methyl methacrylate) (PMMA) bone were coated with biofilms and quantified by CFU count, confocal microscopy and electron microscopy. Surface roughness and water contact angles were assessed with optical profilometer and optical zoom imaging.

RESULTS:

After 72 hours, biofilms grew more readily on non-polished 3D-printed metals and plastics, such as TiAlV (4.77e7 CFU) and UHMWPE (5.12e7 CFU) compared to polished and machined metals such as HPSS (1.06e7 CFU), Ti (1.25e7 CFU), and CoCr (2.16e7 CFU), ANOVA $p < 0.0001$. The materials with greater roughness and hydrophobicity developed more biofilm than smoother, hydrophilic materials.

DISCUSSION AND CONCLUSION:

Implant materials and characteristics have a strong correlation with biofilm formation, with hand-polishing of metals predicting resistance to biofilm formation. In addition to being mechanically weak and a poor antibiotic release profile, PMMA is also rougher and more hydrophobic than the metal implants, and thus provides an additional surface for bacteria to readily form biofilm. These results may inform implant designs and surgeons may choose materials with reduced biofilm affinity in both septic and aseptic procedures.

