Mapping Bacterial Biofilm on Explanted Orthopaedic Hardware: An Analysis of 14 Consecutive Cases

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INTRODUCTION:

Hardware implanted during primary total joint arthroplasty (TJA) carries a serious risk for postoperative periprosthetic joint infection (PJI), which can cause devastating patient and financial complications. Though biofilm formation on foreign materials is well-known, there is a significant gap in addressing whether certain areas of a prosthetic joint articulation may be more susceptible to biofilm formation than others. Additionally, though biofilm attachment and growth on flat and highly polished surfaces constitutes a large area of research, relatively little is known about how larger surface features, such as ridges, edges, surface elevations, rough patches, and holes effect biofilm growth and formation. The intention of this study was to identify specific locations on infected orthopaedic explanted hardware that are more prone to bacterial attachment and subsequent biofilm formation using a developed implant culturing method (ICM).

METHODS:

A novel ICM was used on explanted components from fourteen consecutive surgical cases involving TJA revision due to suspected PJI. The ICM was utilized to culture biofilm and localize bacterial growth on various knee and hip prostheses. The current study was approved by an institutional review board (IRB) and all patients were provided adequate information about the study prior to being consented before surgery. The ICM achieves a thin coating of brain heart infusion (BHI) agar over the entirety of rinsed, explanted components followed by incubation and observation to visualize direct colony outgrowth over nine days. Presence of growth was recorded, colonies were picked and plated on selective agar to determine the presence of *Staphylococcus aureus*, and specific locations of outgrowth were analyzed for patterns of biofilm accumulation. ICM outcomes were also compared with clinical culturing results and PJI diagnosis based on Musculoskeletal Infection Society (MSIS) criteria.

RESULTS:

The ICM paralleled clinical culturing methods with a sensitivity of 100% and specificity of 57.1%. When compared to MSIS criteria the sensitivity remained at 100% while the specificity increased to 80%. Biofilm accumulation patterns were patchy, heterogenous, and mixed throughout different components, though the non-articulating surfaces between the tibial tray and ultra-high molecular weight polyethylene (UHMWPE) tibial insert showed consistent growth in all ICM positive knee revision cases. Likewise, ridges and edges on individual components consistently harbored biofilm, while growth on articulating surfaces of components was more case dependent.

DISCUSSION AND CONCLUSION: The implant culturing method displays promise in both identifying biofilm on culture-negative PJIs as well as uncovering patterns of growth on total knee prostheses. Consistent growth in the sub-micron space between the tibial tray and polyethylene insert may suggest this region as a protected area from diffusing antibiotics and host defense mechanisms. Biofilm formation observed here and near the edges of the knee locking mechanism may indicate room for improvement during debridement, antibiotics, and implant retention procedures. In addition, the ICM proved successful in culturing pathogens alongside traditional culturing and MSIS criteria for diagnosing PJI. Limitations of this method include an increased possibility for contamination compared to traditional culturing methods, only one type of growth condition utilized per component, and the inability to produce a perfectly even coating around entire components. The implant culturing method helped identify common areas of biofilm growth on both individual components and entire prostheses from 14 TJA revision cases. Understanding where biofilm formation most often occurs on implanted hardware has drastic effects on better understanding the course of these damaging joint infections and treating them in a more targeted fashion.