Study on Agitation for Biofilm Eradication and Reduction: Evaluation of Mechanical Brushing with Sonication and Radiofrequency

Timothy G McManus[1], Michael Fort[2], Gabrielle S Ray, Kaitlyn E Barrack, Kevin J McGuire[3], Michael Brent Sparks[4], George Otoole[5]
[1]Dartmouth Health, [2]Dartmouth-Hitchcock Medical Center, [3]Dartmouth Hitchcock Medical Center, [4]Dartmouth Hitchcock Med Ctr, [5]Biological Sciences

INTRODUCTION:

Biofilm-based implant infections continue to be a major contributor to orthopaedic morbidity, mortality, and cost. The aim of this basic science study is to provide a model to evaluate the impact mechanical brushing, sonication, and radiofrequency have on biofilms harbored on three metallic alloys–titanium, stainless steel, and cobalt-chromium.

METHODS:

Biofilms of Staphylococcus aureus, Staphylococcus epidermidis, Pseudomonas aeruginosa, and Escherichia coli were grown on 540 metal chips. Biofilms were treated with sterile saline irrigation, sonication brushing, or radiofrequency sonication brushing with electric toothbrushes to compare against controls. Biofilm burden was evaluated with crystal violet staining, which provides qualitative visual results and quantitative optical density measurements. ANOVA was performed for quantitative data. Scanning electron microscopy imaging was also used for qualitative analysis.

RESULTS:

Qualitatively and quantitatively, all interventions showed a strong qualitative reduction in biofilm burden (Fig. 1-4). For the S. epidermidis biofilm, there was a significant optical density decrease for the brushing interventions compared to irrigation and control on titanium ($p<0.005$) and cobalt-chromium ($p<0.01$). For the E. coli biofilm, there was a significant optical density decrease for brushing interventions compared to irrigation and control on titanium ($p<0.01$). Interventions demonstrated significant optical density decrease in biofilm burden ($p<0.05$) compared to control for all bacteria and metals with the following exceptions: S. epidermidis control compared to irrigation for all metal chips; S. epidermidis control compared to sonication brushing on stainless steel; P. aeruginosa control compared to all interventions on stainless steel; robust S. aureus control compared to irrigation on titanium (Fig. 5-8).

DISCUSSION AND CONCLUSION:

Our data show consistent reduction in biofilm burden with brushing interventions. While further study is needed, our data suggest mechanical brushing with sonication and radiofrequency may be beneficial tools in reducing biofilm burden on metal orthopaedic implants.