Effect of mechanical ultrasonic and radio frequency brushing on the viability of biofilm treated with antibiotics

Michael Fort, Alton B Daley, Kaitlyn E Barrack, Jackson Namian, Timothy G McManus, George Otoole, Michael Brent Sparks

INTRODUCTION:

Prosthetic joint infections remain a major cost and cause for morbidity in orthopaedics. The formation of biofilm on the implants in particular make the infections difficult to eradicate. Current treatment methods include costly debridement, antibiotics, and implant retentions (DAIRs) and fully prosthesis explants with mixed results. The field of dentistry has effectively used new ultrasonic- and radio frequency-based mechanical toothbrushes to target biofilm removal on teeth.

Our hypothesis is that mechanical brushing with ultrasonic (US) and radio frequency (RF) toothbrushes can effectively remove biofilm from metal commonly used in orthopaedic implants and make these infections more susceptible to antibiotic therapy.

METHODS:

Biofilms of *Staphylococcus epidermidis* were grown for 24 hours on metal chips of either stainless steel (SS), cobalt chromium (CoCr), or titanium (Ti). The chips were then treated with irrigation only, US mechanical brushing, RF mechanical brushing, or no treatment as a control. After treatment, 10ug/ml of vancomycin was added to half of the chips, then incubated for an additional 24 hours. The remaining biofilm was then quantified using colony forming units (CFUs) from aerobic blood agar plate growth. Biofilm reduction was compared between metals, treatment types, and the presence or absence of antibiotics using 2-way ANOVA adjusted for multiple comparisons.

RESULTS:

Experiments were performed with 24 chips per metal in triplicate for a total of 216 chips, 72 chips per each of the three metal types: Ti, CoCr, and SS.

For CoCr, RF and US treatments in combination with antibiotics significantly reduced biofilm viability compared to RF and US treated chips without antibiotics (P=0.0026, P=0.0211, respectively) (Fig. 1b). Additionally, RF treated chips with antibiotics significantly reduced biofilm viability compared to control antibiotic plates and irrigation only plates with antibiotics (P=0.0213, P=0.0025, respectively). US chips treated with antibiotics also significantly reduced biofilm viability compared to irrigation only antibiotic treated chips (P=0.0233) (Fig. 1a).

For Ti, US treatment in combination with antibiotics significantly reduced biofilm viability compared to US treated chips without antibiotics (P=0.0441) (Fig. 2b). Additionally, US treated chips in the presence of antibiotics, significantly reduced biofilm viability compared to control and irrigation only treated chips in the presence of antibiotics (P=0.0166, P=0.0203, respectively) (Fig. 2a).

For SS, RF treatment in combination with antibiotics significantly reduced biofilm viability compared to control and irrigation only treated chips in combination with antibiotics (P=0.0187, P=0.0396, respectively) (Fig. 3a). US treatment in combination with antibiotics significantly reduced biofilm viability compared to control chips in combination with antibiotics (P=0.0448).

DISCUSSION AND CONCLUSION: Mechanical brushing with US was shown to significantly reduce biofilm viability in combination with antibiotics on CoCr and Ti plates compared to brushing alone without antibiotics. This suggests a potential weakening/reduction of the biofilm with US brushing treatment making the remaining bacteria more susceptible to antibiotics. Additionally, our data show that for all three metals, the brushing treatment groups reduced biofilm more significantly than control and irrigation treatment groups even in the presence of antibiotics. For treatment of PJIs with retained implants, our data suggest mechanical US and RF brushing could be an effective tool at reducing the biofilm by making the biofilm-associated microbes more susceptible to antibiotic treatment compared to current DAIR treatment.