Methods of Disinfection of Grossly Contaminated Devitalized Bone for Retained Use in Open Fractures: An in vitro Study

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Purpose: Debridement of open fractures has historically included removal of all devitalized bone to prevent infection. Recent studies have achieved low infection rates when retaining clean devitalized fragments. The optimal method of disinfecting grossly contaminated bone for the purpose of retainment is unknown as previous studies examining bone disinfection were not generalizable to open fractures. This study compared the residual bacterial load and mechanical properties of grossly contaminated cortical bone after disinfection.

Methods: 60 cortical pieces of cadaveric femora (0.5 g) were immersed in live bacterial culture (1 x 108 colony forming units per milliliter, CFU/mL) of log-phase Staphylococcus aureus for 60 minutes. Samples were randomized to 1 of 6 treatments: no treatment, saline irrigation, povidone-iodine irrigation, chlorohexidine irrigation, pasteurization, or autoclave. Samples underwent pulverization and bacterial enumeration of the resulting slurry using a standard viable plate count. The limit of detection was 1 CFU/mL. For mechanical testing, 60 cortical beams (2 mm x 2 mm x 3 cm) harvested from cadaveric femora underwent the aforementioned treatments. Beams from each group underwent 4-point bending. Maximum force to failure, bending stiffness, flexural rigidity, and work to failure were calculated. Groups were compared using analysis of variance with Bonferroni correction.

Results: Mean bacterial load was not significantly different with saline irrigation (4 x 107 CFU/mL) versus no treatment (5 x 107 CFU/mL, P = 1). Povidone-iodine (90 CFU/mL) and pasteurization (250 CFU/mL) treatments resulted in a significantly decreased bacterial load compared with saline and no treatment (P<0.001). Samples treated with autoclave (0.6 CFU/mL) and chlorohexidine (zero, 0 CFU/mL) achieved near-complete or complete disinfection and differed significantly from no treatment and saline irrigation (P<0.001). Autoclave decreased maximum force to failure compared with no treatment (84 N vs 100 N, respectively, P = 0.013). No significant difference was noted in this parameter for the remaining groups. No difference was noted among groups for bending stiffness, work to failure, and flexural rigidity.

Conclusion: Chlorohexidine treatment achieved complete disinfection of a grossly contaminated cortical segment without affecting mechanical properties. Povidone-iodine, chlorohexidine, pasteurization, and autoclave disinfection achieved profound reductions in bacterial load. Autoclave modestly decreased the mechanical properties of cortical bone. Our model utilized purely cortical segments and a higher concentration of bacterial inoculum compared with previous studies and thus may be more generalizable to open fractures. Future work will focus on optimizing compound concentrations, bone healing potential, and determination of cell viability after treatment.