Effect of Mixing Vancomycin and Tobramycin with Acrylic Bone Cement on Elution Rates and Mechanical Properties

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INTRODUCTION:
Antibiotic bone cement is used in a two-stage procedure to suppress severe infection after total joint arthroplasty. Implants are removed and replaced with acrylic bone cement utilized as a joint spacer. Common surgical practice involves mixing one or a combination of antibiotics with the cement to increase the potency against infection by localized delivery at higher concentrations than solely oral antibiotics. Ongoing debate continues over antibiotic selection and what concentrations should be used. It remains unclear how specific concentrations of antibiotics influence bone cement in relation to elution and mechanical properties. This study aimed to characterize the mechanical properties of bone cement and antibiotic release after cement preparation with varying concentrations of tobramycin and vancomycin antibiotics.

METHODS:
Commercially available polymethyl-methacrylate (Simplex P, Stryker Orthopaedics, Mahwah, NJ) bone cement was mixed with vancomycin and tobramycin antibiotics under vacuum conditions. A total of 9 groups were tested in concentrations of 1.0g of vancomycin with 1.2g, 2.4g and 3.6g of tobramycin, 2.0g of vancomycin with 1.2g, 2.4g and 3.6g of tobramycin and 3.0g of vancomycin with 1.2g, 2.4g, and 3.6g of tobramycin. Each test group was subjected to a 96 hour period immersed in phosphate buffered saline (PBS) solution with samples taken at predetermined time points.

Fluid samples were subjected to high performance liquid chromatography (Shimadzu, Columbia, MD) for quantification of vancomycin concentration during the elution period. Both eluted and non-eluted samples were subjected to compressive testing using a mini-bionix II load frame (MTS Systems, Minneapolis, MN).

RESULTS:
Antibiotic concentration of vancomycin eluted from cement was higher as the initial concentration of vancomycin stayed the same and tobramycin concentration increased. Figure 1 shows the concentrations of vancomycin for the groups containing 2.0g of vancomycin with 1.2g, 2.4g and 3.6g of tobramycin over the elution period.

Cumulative release increased approximately 290% from 5.1 mg to 20.0 mg between groups with 1.2g and 3.6g tobramycin and 2g of vancomycin, respectively.

Further analysis of mechanical strength showed that ultimate compressive strength (UCS) increased in all groups comparing eluted samples to non-eluted samples except in the group containing the highest initial antibiotic concentrations (3.0g vancomycin with 3.6g tobramycin). UCS in this group was highly variable with average strengths below the ASTM minimum value of 70 MPa for both eluted and non-eluted samples. UCS values are reported in Figure 2.

DISCUSSION:
Results from this study indicate that the addition of tobramycin to bone cement increases the elution of vancomycin and the elution period leads to increased mechanical properties. However, UCS was recorded below the recommended minimum value when more than 6g of antibiotics were initially mixed together. The increase of UCS after the elution period for all test groups indicates that a secondary event may be occurring during elution periods. Previous research indicates a posthardening or late polymerization process may be occurring while submerged, which could be responsible for in the increase in mechanical properties. The change in mechanical strength over time may influence a surgeons’ decision for a patient’s post operative care.

The addition of tobramycin to bone cement may be used to increase the elution of vancomycin directly to the infected area. Ultimately, an individual patient’s case dictates the need for specific antibiotic concentrations.

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