

Elution Characteristics of PMMA Bone Cement Intramedullary Spacers Impregnated with Vancomycin and Tobramycin

*Andrew Patton, MD; Brandon Perez, MD; William Buford, PhD;
University of Texas Medical Branch, Galveston, Texas, USA*

Purpose: Septic nonunion following intramedullary (IM) stabilization of tibial shaft fractures is typically treated with removal of the IM nail (IMN) followed by either IM antibiotic-impregnated polymethylmethacrylate (PMMA) bone cement beads with external fixation stabilization or, more recently, various antibiotic cement-coated IM nailing techniques. As PMMA beads are classically left for 6 to 8 weeks to treat various orthopaedic infections, it became the consensus among orthopaedists that PMMA IMNs also remain 6 to 8 weeks, as reflected in the literature. Although elution kinematic studies have been described for cement beads and small block spacers, no study, to our knowledge, has evaluated the elution properties of long cylindrical IM cement spacers.

Methods: Two antibiotic-impregnated bone cement groups were prepared. Group 1 (Beads) contained 1.0 g of powdered vancomycin and 1.2 g of powdered tobramycin mixed in 40 g of bone cement and rolled into small spheres before placing inside a 40-French fenestrated chest tube. Group 2 (Nails) consisted of 2.0 g of powdered vancomycin, 2.4 g of tobramycin, and 80 g of bone cement, which was fashioned into an IMN using a 40-French chest tube. Ten samples were made for each group. The samples were then placed in PVC piping with 220 mL of normal saline and watertight seal was ensured. Groups were placed in an oscillating shake water bath at 37°C with 1.0 mL testing samples taken from the enclosed PVC piping every 24 hours with replacement of the 220 mL normal saline solution. At day 7, the testing interval was extended to every 7 days for a total of 6 weeks of testing. Concentrations of vancomycin and tobramycin in the testing samples were then determined and compared between the two groups using t tests and Fisher exact tests.

Results: Group 1 (Beads) showed high rates of elution early with logarithmic release of vancomycin; however, by the 6th day of testing the concentration dropped below the detection threshold of 5 µg/mL. Group 2 (Nails) showed early elution of vancomycin less than one-third that of Group 1 Beads, and by the 3rd day of testing the concentration fell below 5 µg/mL. Although brief, this difference was significant ($P < 0.004$). The elution rates of tobramycin showed high rates of antibiotic release with exponential decay as seen with vancomycin. At each time point, beads showed higher elution rates than nails with statistical significance shown up to week 4 of testing. The mean total of tobramycin released in Group 1 was 296.0 µg and 81.9 µg in Group 2.

Conclusion: With the drawbacks of external fixation, more surgeons are looking for treatment options to avoid its application. Various PMMA IMN constructs have been described to provide stability of the fracture but at the expense of antibiotic delivery. In this evaluation of elution rates of PMMA antibiotic-impregnated beads and long cylindrical IM nails, the antibiotic beads proved statistically superior.