Paper Session: Infection and
Fracture Healing

The Induced-Membrane Technique: Effects of Antibiotic-Impregnated Spacers on Healing of a Critical-Size Femoral Defect in a Rat Model

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Purpose: The induced-membrane technique (IMT), also known as the Masquelet technique, is a therapeutic option that is being increasingly employed for management of bone defects. Although not described in the original reports of the technique, surgeons now frequently incorporate antibiotics into the spacer to prevent or treat infection. However, the effects of such antibiotic concentrations on bone healing are not clear. Since antibiotic-impregnated spacers have already gained widespread clinical use in the IMT, there is a need to understand if this common practice impacts the critical goal of bone repair.

Methods: Male Fischer 344 rats were randomly divided into 3 groups according to the spacer used during the first stage of the IMT: (1) control (PMMA [polymethylmethacrylate] alone), (2) low-dose antibiotics (1.2 g tobramycin + 1.0 g vancomycin per 40 g of PMMA), and (3) high-dose antibiotics (3.6 g tobramycin + 3.0 g vancomycin per 40 g of PMMA). To model the IMT, we created a 5-mm segmental defect in the right femoral diaphysis of each rat. The bone was then stabilized with a plate and screws. Next, a spacer was inserted into the defect in accordance with the treatment group. Four weeks later, we replaced the spacer with morselized bone graft from an isogenic donor rat, standardized by weight. For 12 weeks, biweekly radiographs were taken and scored in a blinded fashion according to union status and a modified 16-point Lane and Sandhu scoring system. Micro-CT was used to quantify the bone mineral density (BMD) and bone volume (BV).

Results: Radiographs at 12 weeks following grafting demonstrated complete union in 83.3% (10/12) of control animals, 100% (13/13) of low-dose animals, and 66.7% (8/12) of high-dose animals. Average Lane and Sandhu scores were 10.17 (3.26), 12.08 (0.91) and 10.29 (2.76) in control, low-dose, and high-dose groups, respectively ($P = 0.11$). Micro-CT demonstrated higher BV in the control (37.49 mm3 ± 11.39 standard deviation) and low-dose (36.58 mm3 ± 5.90) groups relative to the high-dose group (28.37 mm3 ± 8.75). These differences were statistically significant comparing control and high-dose ($P = 0.0436$), but not statistically significant comparing high-dose to low-dose ($P = 0.0684$). BMD showed no significant differences between any groups.

Conclusion: In this animal model of the IMT, we found that PMMA spacers without antibiotics and those with low-dose antibiotics had higher rates of radiographic union compared to spacers with high-dose antibiotics. Micro-CT analysis suggests that incorporating antibiotics in high doses adversely affects bone formation. In the context of the IMT, our results suggest that high doses of antibiotics in PMMA may negatively impact bone healing. Further investigation is needed to determine the optimal antibiotic dosage and the extent to which antibiotics impact functional bone healing.