

Impact of Implanted Shrapnel-like Pellets on Bone Integrity in Rats after One and Three Months

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ABSTRACT

Depleted uranium (DU) and heavy metal tungsten alloys (HTMA), composed of tungsten, nickel, and either cobalt or iron, are used as kinetic energy penetrators in military applications. Due to this use, thousands of military service members experience shrapnel-related injuries. Since surgical removal could cause excessive tissue damage, these fragments are often left in place; however, the long-term health implications of leaving these fragments in the warfighter's body is poorly understood. Preliminary evidence has shown bone tissue is a primary reservoir for storage of uranium, where it takes the place of calcium in the bone mineral matrix. The purpose of this study was to examine the effects of embedded DU and HTMA pellets on bone mineral density (BMD) and bone mineral content (BMC), key predictors of bone strength, in rat bone. Femurs from male Sprague Dawley rats (~ 20-24 weeks old) had either DU, Tungsten/Nickel/Iron (WNI_{Fe}), Tungsten/Nickel/Cobalt (WNI_{Co}), or Tantalum (an inert metal serving as control) pellets inserted intramuscularly (2 pellets/hindlimb). Tissues were collected from 8-10 rats at both 1 month and 3 months following the insertion of the pellets. Distal femur metaphyseal and cortical shaft BMD and BMC were measured via peripheral quantitative computed tomography (pQCT). After one month, cancellous BMD and BMC were slightly higher in WNI_{Fe} and DU compared to WNI_{Co} embedded animals. After three months, there were significant increases in total metaphyseal BMD, cancellous BMD, and total metaphyseal area in DU and WNI_{Co} ($p \leq .001$). There were no changes seen in metaphyseal BMC and cortical bone at the midshaft of the femur. This is one of the first studies to examine the effects of shrapnel-like alloys on bone integrity. These data demonstrate that DU and WNI_{Co} increased BMD in the metaphysis; however, if these metals are replacing calcium in the bone matrix, the increased BMD may not be beneficial to bone. As DU becomes more prevalent in the bone matrix, calcium levels may decline, which could cause an increased risk of fractures with age. Therefore, more research is required to determine the impact of these shrapnel metals on bone mechanical properties, fracture risk, and long-term health.