Purpose:
This study simulates at the cellular scale the microscopic dose enhancement from high Z materials (such as gold nanoparticles) in tissue as a function of concentration and intracellular localization.

Methods:
Monte Carlo (MC) simulations were performed using Geant4 9.3p02 for a simple 3D geometry of 125 cubic cells with centered nuclei. Contrast materials of gold, iodine, and tungsten were simulated in a 150 kVp beam. The extra- and intra-cellular contrast concentration was varied, and internal cellular contrast was placed either throughout the cytoplasm or in localized vesicles.

Results:
The enhancement factor for the nucleus is well described by a linear function of tissue contrast, regardless of whether the enhancement agent was contained in vesicles or throughout the cytoplasm. The predicted enhancement is smaller than previous simulations using macroscopic methods and is smaller than measured values.

Conclusions:
Cellular scale simulations show that macroscopic simulations overestimate the enhancement seen in the nucleus, but that intermediate energy secondaries interacting in the nucleus would not provide the enhancement measured experimentally.

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