

Purpose: To quantitatively compare fractions of dose enhancement in microscopic ranges (m-DEF) due to gold nanoparticles (AuNP) with different sizes using Monte Carlo simulation.

Material and Methods: PENELOPE Monte Carlo code was used to perform simulations of dose deposition. The history condensation parameters of the event-by-event electron simulations were set as 0.05 maximum fraction of energy loss and 0.05 maximum fraction of angular deviation per interaction. Two clinical energy spectrums were considered in this study: Ir-192 HDR brachytherapy source and 200kV ortovoltage beam. Six AuNP spherical sizes were simulated from 10nm to 150nm. Nanoparticles were positioned inside a virtual spherical cell and total gold concentration was 0.01% mass fraction. Doses were recorded inside the cell and m-DEFs were calculated as the ratio between total dose deposited inside the cell with and without nanoparticles.

Results: A non-linear relation was found between nanoparticle size and m-DEF to both clinical beams considered. The m-DEF found to 50nm particles enclosed to the cell in 200kV and Ir-192 simulations were 1.73 and 1.56, respectively. This value becomes lower than 1.20 when 150nm nanoparticles are considered to both energy beams. When particles in a range from 10nm to 40nm are considered, the m-DEF found was lower than 1.40, being higher to 200kV beam. Standard deviations are around 5% to 10nm simulations and decreases fast with particle size, reaching 1% to 150nm AuNP particles.

Conclusions: Microscopic dose enhancement fractions are dependent to gold nanoparticle size and this relation can be studied by Monte Carlo when properly statistical analysis is applied. An optimized size of gold nanoparticle can be determined according to radiation therapy beam of interest. The size dependence of m-DEF has its origin in the range of the electrons created inside the AuNPs that delivery doses inside the cells, being more expressive to large sizes.