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18 MV Radiation Sensitivity Comparison of Platinum and Gadolinium Oxide Nanoparticles using Magnetic Resonance based MAGICA Polymer Gel Dosimetry

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INTRODUCTION

According to 5R principle of Radiobiology it is possible to enhance the effects of radiation therapy on fractional regimens. The fifth principle is the intrinsic radiosensitivity. It can be achieved by some agents that known as interaction. It is a technique that increases the effect of radiation in the tumoral tissue compared with the normal tissue surrounding. For this purpose, compounds of high-atomic materials have been used. It can attenuate X-ray mainly through the photoelectric phenomenon, which results in the formation of secondary radiation and hence increase absorbed dose in the target. In the last decade, elements have been utilized in nanoscale as a radiosensitizer. The higher specific surface area of nanoparticles than microparticles makes it possible that more electrons to be available for beam interaction. These electrons are responsible for the interaction of matter with the beam.

AIM

The aim of this study was to compare the radiation sensitivity between Platinum nanoparticles (PtNPs) and Gadolinium oxide nanoparticles (GdNPs), through the use of 18 MV photon beam via measuring dose enhancement factor (DEF) using MR-based MAGICA polymer gel dosimeter.

METHOD

The MAGICA polymer gel was first prepared in laboratory, then PtNPs and GdNPs, with average diametesr of 35 nm, respectively, were embedded in MAGICA gel vials and then irradiated with 18 MV photon beams. These vials were imaged by 3T MRI Simence scanner using head coil, 24 hours after irradiation.

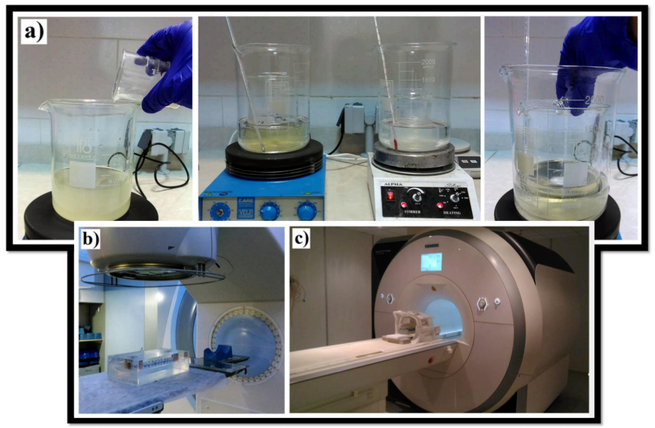

Figure 1. a) fabrication of MAGICA gel dosimeter; b) irradiation conducted on a 18-MV photon beam delivered by a linear accelerator; c) gel read out by MR scanning using a head coil.

RESULTS

MAGICA gel, PtNPs and GdNPs responses to the 18 MV x-ray beam were determined by R2 signal relation to Dose. As shown in the figure 2, the dose dependence of the transverse relaxation rate, R2, is reproducible and all dose responses are almost linear between 0 and 5Gy. Radiation Dose Enhancement Factor (DEF) in the specified ROIs is computed by using the following equation. In which R2 (NP+Gel) is defined as the ratio of dose dependence in the transverse relaxation rate, R2, with the nanoparticle and R2 (Gel) is the relaxation rate without the nanoparticle.

$$DEF\% = \left[\frac{R_2(NP+Gel) - R_2(Gel)}{R_2(Gel)}\right] \times 100$$

DEF values for two nanoparticles (PtNPs and GdNPs at 0.1 mM concentration) were compared under different dose irradiation from 0 to 5 Gy shown in figure 2c. The result shows up to 2 Gy dose irradiation, the DEF value for PtNPs and GdNPs were 6% and 8%, respectively. However, for 3 to 5 Gy dose irradiation, while the amount of DEF of GdNPs remained almost stable to 8%, but for PtNPs increased considerably to 11% at 5Gy in concentrations of 0.1 mM.

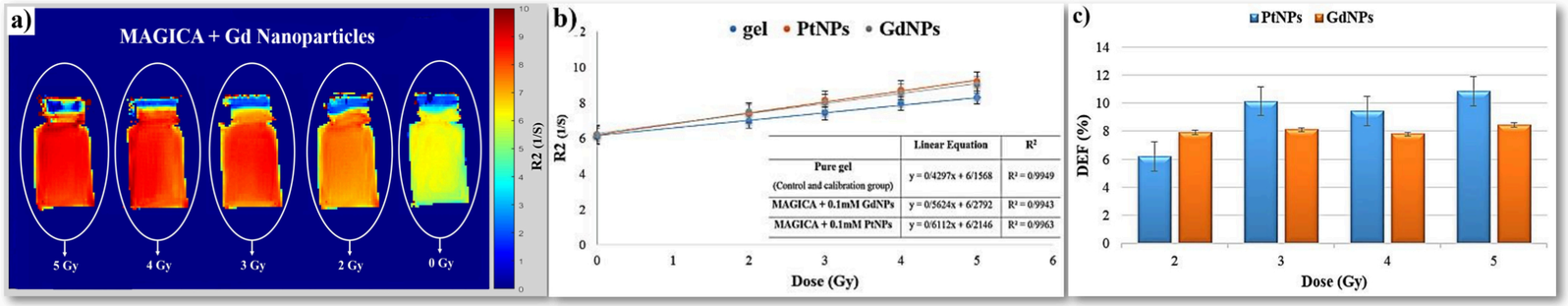

Figure 2. a) an example of an R2 map obtained from coronal MR images computed by a program coded in the MATLAB; b) dose-response curve for pure MAGICA gel, PtNPs, and GdNPs irradiated with an 18 MV X-rays; c) Comparison of DEF values for PtNPs and GdNPs at 0.1 mM concentration under different dose irradiation.

CONCLUSIONS

The results showed that owing the higher amount of DEF in PtNPs relative to GdNPs up to 11%, as well as, due to its higher atomic number of 78 than that of GdNPs (64), therefore, PtNPs is more sensible to conclude that using MAGICA with PtNPs for clinical purpose would be more effective at high energy application of 18 MV. MAGICA gel polymer is also an appropriate for investigation of nanoparticles effects due to easy preparation, dose distribution and other merits that mentioned previously.

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