

Evaluation of Bismuth Oxide Nanoparticles (BiONPs) as a Safe Radiobiological Enhancer for Breast Cancer Radiotherapy

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Abstract

Cancer incidence has been increasing over the years and it is the second leading cause of death globally ^[1]. The therapeutic strategies in killing the cancerous tissue while keeping the normal healthy tissue uninterrupted can be further improved by introducing nanoparticles (NPs) as radiosensitizers in radiotherapy. In pre-clinical research, a few nanoparticle elements had shown the potential to be radiosensitizers, such as gold, superparamagnetic iron oxide, platinum, and bismuth nanoparticles. Bismuth oxide nanoparticles (BiONPs) have been investigated as a potential radiosensitizer in radiotherapy due to their least toxic and biocompatibility properties. In addition, due to the presence of metallic nanoparticles in cells and their environment, more DNA damage will be introduced and thus enhance the radiation treatment efficacy.

This research project was conducted to evaluate the potential of BiONPs to increase the radiation treatment in MCF-7 breast cancer cells and their side effects on the non-targeted breast cancer cells. BiONPs were synthesized through the hydrothermal method, as established in the previous study ^[2]. The treated and control cells in flasks were irradiated with radiation doses between 0 to 12 Gy at a constant dose rate of 300 cGy/minutes in the beam field size of 10 cm x 10 cm for a 6 MV photon beam, delivered with linear accelerator Primus model (Siemen Healthcare, USA). The irradiated cell-conditioned medium (ICCM) was collected from the targeted cells and transferred into the non-targeted cells. The cell viability assay was employed to evaluate the effect of BiONPs on directly irradiated and non-irradiated cells.

In our prior work, the BiONPs had shown to boost radiosensitisation effects in treated cells compared to control cells, with a sensitisation enhancement ratio (SER) of 1.38 ^[3], as shown in Figure 1. The increased radiosensitisation effects might be attributed to the characteristics of BiONPs with a high effective atomic number (Z=83), which promotes radiation interaction, mainly radiation absorption and scattering. Meanwhile, the present study demonstrated that the non-irradiated MCF-7 cells could maintain their cell viability for more than 80% after 48 h incubation with ICCM treated with BiONPs at 2, 6, and 12 Gy. Furthermore, a comparable trend in cell viability was observed in non-irradiated MCF-7 cells for treated and control groups (p<0.05), as illustrated in

Figure 2. This finding indicated that BiONPs are not harmful and do not contribute to side effects in non-targeted cells.

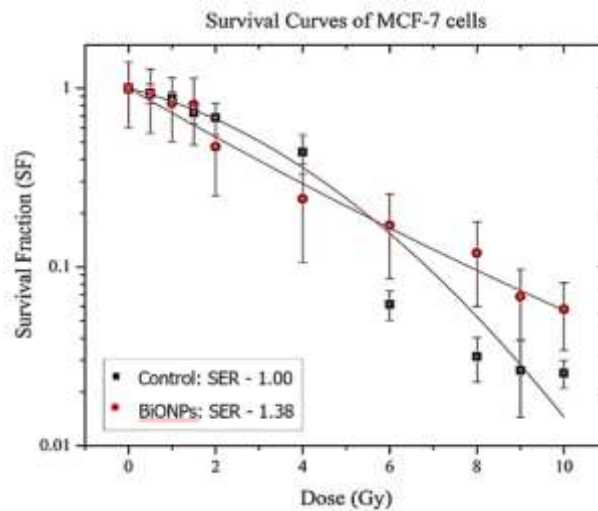


Figure 1: Survival curves of control and BiONPs treated on MCF-7 cells with a 6 MV photon beam at doses range of 0 to 12 Gy. The survival data were fitted to linear-quadratic (LQ) models. The figure is modified, and the SER values of BiONPs treatment were referred to in our prior work.

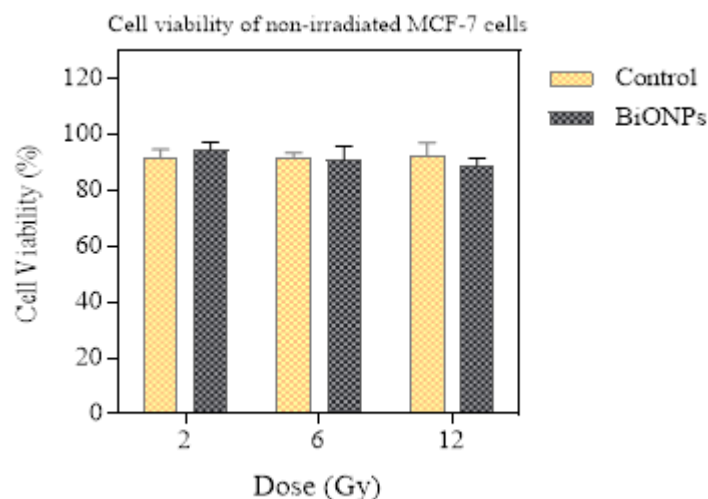


Figure 2: Percentages of cell viability in non-irradiated MCF-7 cells treated with BiONPs compared to control groups at 2, 6, and 12 Gy doses.

The present works have provided evidence that using BiONPs as radiosensitizers in radiotherapy is safe and does not significantly introduce side effects in the non-targeted cells. These data proved the impacts of BiONPs as a potential tool for a safe radiobiological enhancer that will benefit future radiation therapy strategies in cancer management.

Keywords

Bismuth oxide nanoparticles, Breast cancer, Radiotherapy

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