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Cold Plasma Targeted Redox Therapy for Breast Cancer Bone Metastasis

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Bone, especially the spine, is a common site for metastasis from breast, lung, and prostate cancers, often requiring aggressive treatments like chemotherapy and invasive surgery. These surgeries usually involve removing both the tumor and surrounding healthy tissue, creating voids that need reconstruction. Cold plasma therapy, operating at temperatures below 40℃, offers a non-invasive alternative by delivering reactive oxygen and nitrogen species (RONS) locally to the tumor site. However, understanding the precise interactions between plasma and tissues, along with determining the optimal treatment dosages, remains an active area of research. This project aims to develop a cold plasma source and investigate its potential to inhibit bone cancer metastasis, focusing on its anti-tumor effects. A platform was developed, combining a kHz coaxial dielectric barrier discharge plasma source with a bioprinted tumor-stroma interface model. The model, made of a cell-laden hydrogel (1% alginate and 7% gelatin), replicates a bone-like microenvironment by coculturing MDA-MB-231 breast cancer cells with human bone marrow mesenchymal stem cells (hbmMSCs). The effects of plasma treatment on cancer and healthy cells were measured through metabolic activity and live/dead assays over several days. Results demonstrated that the bioprinted hydrogel model was reproducible, and plasma treatment selectively targeted MDA-MB-231 cells while sparing hbmMSCs in both 2D and 3D cultures. Dose responses were evaluated, showing that plasma treatment parameters, including energy, gas composition, distance, and duration, could be fine-tuned to optimize the antitumor effects. Additionally, colorimetric assays confirmed that the production of long-lived reactive species (H2O2 and NO2-) could be controlled through these plasma parameters. This selectivity highlights the potential of plasma therapy as a targeted treatment for cancer, minimizing damage to healthy tissue. This research presents a promising platform for exploring cold plasma as a personalized, non-invasive treatment option for bone metastases, with the goal of integrating this technology into clinical practice.

Keyword-1

Cold Plasma

Keyword-2

Cancer

Keyword-3

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