Investigating the Potential Benefits of Proton Therapy in the Context of Neurodegenerative Disorders

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Ionizing radiation is widely employed for medical purposes, encompassing both diagnostic and therapeutic applications. Radiation therapy, a well-established medical modality routinely employed in cancer treatment, has demonstrated efficacy in addressing extra-cranial amyloidosis. Current evidence suggests its potential as a promising treatment for amyloid-associated neurodegenerative disorders, and emerging modalities could enhance biological effects while mitigating potential toxicity.

Proton therapy stands out as one of the most effective radiation therapy techniques, due to the considerable clinical advantages of protons over conventional radiation therapy particles such as photons or electrons. These advantages include a favorable depth dose distribution, reduced lateral spread, and minimal scatter, facilitating a decrease in collateral damage. While this modality is currently undergoing testing in cancer settings, its application in the context of amyloidosis and neurodegenerative disorders remains largely unexplored.

In our multidisciplinary research, ionizing radiation is being investigated as a potential treatment for neurodegeneration, with the capability to disassemble amyloid structures through the disruption of chemical bonds or by triggering cellular degradation mechanisms. We aim to simulate different radiation modalities using Monte Carlo tools (TOPAS/Geant4) and experimentally validate their effects on those abnormal protein deposits. The preliminary gamma-irradiation experiments conducted on cell lines expressing neurodegenerative disease-associated proteins, demonstrated a decrease in the expression and aggregation of the pathological proteins, which was proportional to the applied dose. Subsequently, we progressed to irradiating biological samples with photons and electrons using a clinical linear accelerator at a medical facility. To conduct experiments on biological models, the establishment of a system facilitating the desired measurements is crucial, emphasizing the need for reproducibility, ease of assembly, and swift setup. A phantom designed for cell irradiation at radiotherapy clinical facilities underwent characterization, requiring the implementation of Monte Carlo simulations with TOPAS.

In this presentation, we will showcase the results of the dosimetric characterization of the designed and constructed phantom. Additionally, we will provide an update on the ongoing irradiation experiments conducted at the clinical linear accelerator, encompassing both photons and electrons. Our ongoing research is dedicated to laying the groundwork for the expansion of proton therapy applications beyond cancer. This expansion aims to amplify the adaptability of emerging proton therapy facilities and potentially transform the course of development for presently incurable neurodegenerative disorders.