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Towards Personalized Microbeam Radiation Therapy for Brain Cancer Treatment

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Brain cancer is a detrimental disease with poor long term prognosis. The most common type of brain cancer, glioblastoma, has an associated 5 year survival of only 5% in Australia [1]. New treatments are therefore highly sought after to overcome the glioblastoma resistance to radiation and chemotherapy. Microbeam Radiation Therapy (MRT) at the Imaging and Medical Beam Line (IMBL) of the Australian Synchrotron implements ultra-fast radiosurgical cancer treatment with 50 μm microbeams spaced 400 μm apart [2].
This study reports the brain cancer treatment efficacy of individualized MRT at the IMBL delivered in a single fraction with results from the first long-term MRT pre-clinical trial in Australia. The personalized treatment approach used state of the art dosimetry, new image alignment systems, cell studies and preclinical treatments performed at the IMBL. A 9L gliosarcoma brain cancer model was investigated in vitro with MRT and synchrotron broad beam to understand the cell response to the ultra-fast X-ray treatment. Following this, juvenile (8-week old) male Fischer rats were injected with intracerebral 9L gliosarcoma cells. Twelve days later, the rats received MRT following individualized image alignment based on individual tumours imaged on day 11 performed at Monash Biomedical Imaging. Treatment efficacy was evaluated in terms of in vitro cell survival, long term preclinical survival, histological brain and tumour morphology, and a pioneering assessment of the individual MRT tumour dose-coverage (Figure 1).
The results of our study reveal the relationships between the in vitro cell response, tumour dose-volume coverage and survival post MRT irradiation of a radioresistant brain cancer in a rodent model. The synchrotron radiation therapy (both MRT and broad beam) showed improvements over the conventional (low dose rate) treatment of 9L cells, providing evidence for an in vitro dose rate dependence and FLASH effect. Preclinical studies showed that MRT increased the mean lifespan of rats by 570% compared to unirradiated controls. Individuals responded to MRT based on their tumour dose coverage with depth and tumour size (Figure 1).
This innovative and interdisciplinary approach provides an in-depth understanding of brain cancer treatment using MRT at the Australian Synchrotron. The developments made in this work are the first steps towards personalized clinical strategies using MRT. The extension of this work to larger animals is required, but may ultimately improve the outcome for young patients with brain cancer.

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References

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