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From palliative to curative microbeam radiation therapy at the Australian Synchrotron: Increasing the irradiated area to achieve complete coverage of the tumor

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Radiation therapy is an important component of cancer treatment. Microbeam radiation therapy (MRT) is an experimental irradiation technique in which a synchrotron-generated X-ray beam is spatially fractionated into an array of quasi-parallel microbeams by a multislit collimator, leading to an inhomogeneous dose distribution in the target. In preclinical studies, this results in good tumor control and better tolerance for healthy tissue.

Currently, MRT is often used in unidirectional mode with a single treatment field that is limited in width to 30 mm due to the lateral roll-off in intensity of the synchrotron generated X-ray beam. In a veterinary study at the Australian Synchrotron, dogs with tumors (bone cancer) in their legs have received only partial tumor irradiation as palliative treatment. To irradiate larger tumors with curative intent, we propose to increase the irradiation field by laterally patching multiple microbeam arrays and rotate them around the isocenter to achieve complete coverage of the tumor. Dose fractionation at the micrometre scale and irradiation from multiple angles, similar to the clinically already established stereotactic radiotherapy, makes dosimetry extremely challenging. Equally interesting is the correlation between spatial dose distribution and radiobiological response. To explore the latter, we have conducted in-vitro studies in human brain and lung cells at the Imaging and Medical Beamline (IMBL) of the Australian Synchrotron and at the P61A beamline of the PETRA III synchrotron on the DESY campus in Germany as part of an international collaboration project between Australian and German research groups. Our initial pre-clinical results demonstrate with high precision that both patching and rotating MRT arrays can be executed reliably and without compromising treatment accuracy. Irradiated cells only survived outside the irradiation fields. In an ongoing study, we aim to establish a quality assessment procedure for the curative, complete irradiation of primary and secondary malignant tumors.

Authors: FRERKER, Bernd (Department of Radiooncology, Rostock University Medical Center); SCHÜLTKE, Elisabeth (Department of Radiooncology, Rostock University Medical Center)

Co-authors: HAMADA, Abdul Malek (Department of Radiooncology, Rostock University Medical Center, Germany); HÄUSERMANN, Daniel (Australian Synchrotron/ANSTO, Clayton, Melbourne, Australia); ENGELS, Elette (Centre of Medical Radiation Physics, University of Wollongong; Australian Synchrotron/ ANSTO, Clayton, Melbourne, Australia); NÜSKEN, Frank (Department of Radiooncology, Rostock University Medical Center); HILDEBRANDT, Guido (Department of Radiooncology, Rostock University Medical Center); ABREU FARIA, Guilherme (Helmholtz-Zentrum Hereon, DESY, Hamburg, Germany); FORRESTER, Helen (Royal Melbourne Institute of Technology (RMIT) University, Melbourne, Australia); CAYLEY, James (Centre of Medical Radiation Physics, University of Wollongong, Australia); KLINGENBERG, Johannes (Helmholtz-Zentrum Hereon, DESY, Hamburg, Germany); BUSTILLO, John Paul (Centre of Medical Radiation Physics, University of Wollongong, Australia); KÜGELE, Malin (Department of Radiooncology, Rostock University Medical Center); CAMERON, Matthew

(Australian Synchrotron/ANSTO, Clayton, Melbourne, Australia); LERCH, Micheal (Centre of Medical Radiation Physics, University of Wollongong, Australia); MARTIN, Olga (Centre of Medical Radiation Physics, University of Wollongong, Australia; Institute of Anatomy, University of Bern, Switzerland); FIEDLER, Stefan (European Molecular Biology Laboratory, DESY, Hamburg, Germany); DE ROVER, Vincent Tim (Centre of Medical Radiation Physics, University of Wollongong, Australia); DZIERMA, Yvonne (Department of Radiooncology, Rostock University Medical Center)

Presenter: FRERKER, Bernd (Department of Radiooncology, Rostock University Medical Center)

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