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In vitro exploration of the biochemical processes underlying neon minibeam radiation therapy using synchrotron-based infrared microspectroscopy

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Healthy tissue toxicity limitations of neon beams may be overcome by combining such ions with the remarkable normal tissue sparing that spatially fractionated radiotherapies provide. The present study explores the biochemical effects involved at a single-cell level in neon minibeam radiation therapy (NeMBRT) using synchrotron-based Fourier transform infrared microspectroscopy (SR-FTIRM). This tool can unveil specific biochemical characteristics of samples by analysing their IR absorbance spectra.

Irradiations were performed at HIMAC (Japan). Both healthy (BJ fibroblasts) and tumour (B16-F10 melanoma) cell lines were subjected to conventional neon RT (NeBB) and NeMBRT. 230 Mev/u neon beams were employed to deliver mean doses of 2, 4 and 8 Gy. Biochemical effects were assessed right after irradiations and 24 hours later. SR-FTIRM measurements were conducted at ALBA Synchrotron (Spain). Differences between treatment configurations were assessed with principal component analysis (PCA).

PCA scores separated samples according to their different IR biochemical signatures resulting from irradiations. In fibroblasts, a clear segregation between NeBB and NeMBRT groups was observed, with the latter remaining closer to control samples. The main IR bands affected by irradiations were the amides, suggesting protein secondary structure alterations. NeBB also affected the ester and phosphate bands, pointing to oxidative stress and DNA backbone damage. For the tumour cell line, modifications of IR bands led to separate PCA clusters of all irradiation modalities; NeMBRT peak group was the most segregated from controls, mostly altering IR bands associated with amide substructures. DNA- and lipid-associated spectral regions were also affected by NeBB and NeMBRT peak groups, which might have resulted from DNA and RNA conformational changes or oxidative stress.

The SR-FTIRM capabilities allowed to uncover the biochemical responses of healthy and cancerous cell lines to NeMBRT, suggesting the activation of distinct effects for both. Specific spectral differences between irradiation configurations were dose-, time- and cell line-dependent.

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