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Abstract Title: RBE Evaluation of a 2D Ripple Filter applied in Carbon Ion Therapy Using Microdosimetric Methods

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Background / Aims:

Carbon ion therapy (CIT) offers superior precision through enhanced biological effectiveness (RBE) and improved organ sparing. At SPHIC, a clinical 2D ripple filter optimizes treatment efficiency by reducing delivery energy layers. This study employs microdosimetry to quantitatively evaluate the RBE of this optimized beam configuration on human salivary gland cells.

Subjects and Methods:

- Experimental Setup: Microdosimetric measurements performed using two detectors: Tissue-Equivalent Proportional Counter (TEPC), Silicon-On-Insulator (SOI).
- Measured plans: Two Spread-Out Bragg Peaks (SOBPs) with identical clinical prescriptions were compared. Compared a conventional (non-ripple) filter vs. the novel 2D ripple filter.
- Data Analysis: Microdosimetric spectra were acquired at various depths. The derived $\bar{y}D$ values form the basis for subsequent RBE_{10} calculation.

Result:

- Mean Lineal Energy ($\bar{y}D$): A significant increase was observed from the entrance (12.03 keV/μm) to the distal region (115.79 keV/μm) for the 2D-RFi SOBP, as measured by TEPC.
- Corresponding RBE_{10} Values: This physical dose change translated to a rise in biological effectiveness from RBE 1.1 (entrance) to RBE 2.4 (distal), calculated via the modified MKM.
- Impact of the 2D Ripple Filter: A measurable deviation in $\bar{y}D$ was found when comparing SOBPs with and without the 2D-RFi (~20% in build-up, ~6% in flat region). Crucially, this physical difference resulted in a negligible RBE variation of <5%.
- The 2D ripple filter achieves a significant enhancement in irradiation efficiency without clinically compromising the RBE.

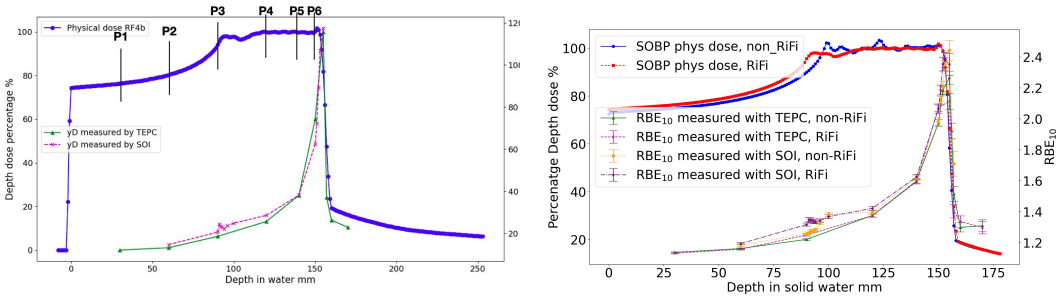

Figure: (Left) Physical dose & mean lineal energy ($\bar{y}D$) across a 6×6×6 cm^3 carbon SOBP, measured by TEPC and SOI detectors. (Right) RBE_{10} values derived via MKM, based on $\bar{y}D$ measurements with/without the 2D ripple filter.