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Dosimetric procedures for FLASH-RT biological experiments

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Introduction
Recently, some of the established concepts governing the effects of radiation on healthy tissues were questioned by a new treatment modality using ultra-high dose-rates called FLASH radiotherapy (FLASH-RT). To this day, no metrological traceability for FLASH-RT dosimetry exists and no monitoring instruments can determine on-line the delivered dose during biological experiments. The aim of the study was 1) to conduct a redundant evaluation of the dose with different measurement means, as a surrogate for metrological traceability and 2) to implement a dosimetric procedure for biological experiments.
Materials and Methods
The experiments were conducted on the Oriatron eRT6 (PMB-Alcen, France), a prototype high dose-per-pulse linear accelerator delivering a 6 MeV pulsed electron beam with dose-rates ranging from conventional (a few Gy/min) to ultra-high (>1000 Gy/s). To ensure minimal uncertainties in the delivered dose, a two-phase procedure was developed. First, in order to achieve traceable, repeatable and stable irradiations, a redundant dosimetry with alanine, Thermo-Luminescent Dosimeters (TLD) and radiochromic films was conducted to investigate absolute dosimetry for FLASH-RT. Then, for biological experiments, a dosimetric procedure was implemented prior to irradiation to ensure the delivered dose. Three typical biological setups are presented together with the beam characteristic and dosimetry.
Results
Alanine, TLDs and films are suitable dosimeters for absolute dosimetry for irradiations with dose-rates between 0.078 Gy/s and 1050 Gy/s (dose agreement of 3% between them). When applying our dosimetric procedure prior to irradiation, the maximum deviation between the delivered and prescribed dose was less than 3%. Dose deviations up to 15% of the prescribed dose could be achieved in the absence of setup corrections (i.e. without dosimetric procedures).
Conclusion
Thanks to the validation of several dosimetric means, we were able to develop procedures to accurately irradiate biological models. An agreement of 3% between the delivered and prescribed dose was achieved.

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