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End-to-end tests with alanine pellets read by EPR in a heterogeneous phantom for radiotherapy treatments

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Context: To calculate the dose delivered to patients treated by radiotherapy, Treatment Planning Systems (TPS) rely on dose calculation algorithms with known limitations including the management of heterogeneities and small fields. This work aims at evaluating the TPS performance in such critical conditions by performing end-to-end tests in a heterogeneous phantom with the alanine / electronic paramagnetic resonance (EPR) technique.

Materials and methods: Inserts suitable for alanine dosimeters were designed to perform end-to-end tests using alanine pellets positioned in different regions: normal tissue, lung or bone region of the CIRS 002 LFC thorax phantom (Figure 1). Irradiations were undertaken using a Varian medical accelerator for eleven different configurations. Measurements were also conducted with a CC04 ionization chamber (IBA). Dose to water calculations were performed with the Eclipse TPS (Varian) using the two Anisotropic Analytical Algorithm (AAA) and the AcurosXB (AXB) algorithms. Comparison between measured and calculated doses were performed for a reference field and for clinical treatment plans performed with either Dynamic Conformational Arctherapy (DCA) or volumetric Modulated ArcTherapy (VMAT).

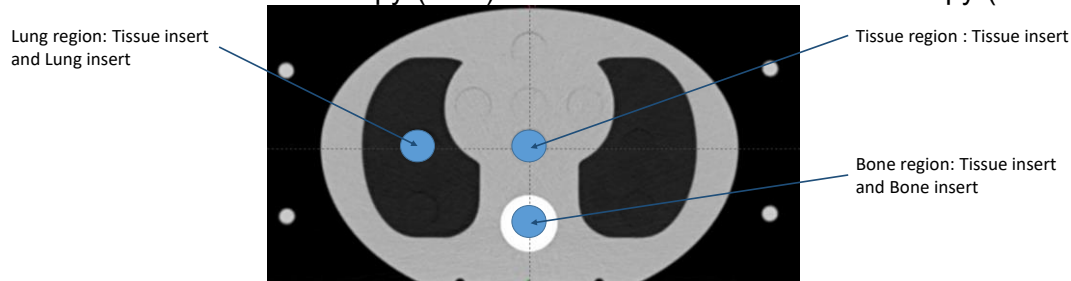


Figure 1: Description of the configurations studied on a Computed Tomography slice of the CIRS Thorax phantom

Results: In all irradiation configurations, the Eclipse AXB algorithm calculations agree with the alanine dosimeter measurements within the uncertainties, with a coverage factor $k = 2$. For the Eclipse AAA algorithm, calculations agree with the alanine dosimeter measurements within the uncertainties, with a coverage factor $k = 2$, for all irradiation configurations except for the DCA clinical planes which had the smallest field aperture (2.5 cm x 1 cm) and for which the dose difference is larger than 5 % in the lung region. Ionization chamber measurements overestimate the delivered dose compared to the alanine dosimeter measurements with a discrepancy larger than 6 % in the bone region.

Conclusion: In this work, alanine dosimeters were used to control the dose delivered during end-to-end tests in clinical configurations. Comparison with the ionization chamber highlighted the effectiveness of alanine dosimeters for the phantom bone region. Alanine/EPR technique results revealed the difficulties of the Eclipse TPS AAA algorithm to deal with heterogeneous lung region of the phantom and a small field aperture.

Keywords Radiotherapy; alanine; End-to-end test; Dosimetry; EPR