

Purpose: Optical-CT gel/radiochromic dosimetry has emerged as a promising candidate for 3D dose verification. One factor that affects the accuracy of dose reconstruction in this technique is the refractive index mismatch between the gel phantom and the matching liquid that prevents the full width of the phantom from being used for dose mapping. The purpose of this study is to investigate the effect of the refractive artifact on dose reconstruction, and to identify optimal designs for accurate gel dosimeters.

Methods: Numerical experiments were carried out for a series of model attenuation coefficients of the gel phantom and various degrees of refraction resulting in situations where only projections through certain central sections of the sample are detected. Measured data was obtained as the Radon transform of the model attenuation coefficient. The attenuation coefficient was then reconstructed using the filtered backprojection algorithm. A mathematical study was performed in the framework of the so-called interior problem of Radon transform inversion. The variation of the amount of data accessible experimentally with the refractive index mismatch was investigated using geometrical optics.

Results: It was demonstrated that the reconstruction of the attenuation coefficient within 3% is possible in the central part of the phantom even if only 82.5% of the optical projections are detected. This fraction of available data results from a 1.5% refractive index mismatch between the gel and liquid. Using a priori knowledge of the value of the absorption coefficient at a given point in the sample, it is possible to calculate the correct value at all points.

Conclusions: Optical attenuation and dose in an optical CT gel dosimeter can be reconstructed accurately in the central part of the dosimeter even if only limited data are available. A priori knowledge of the attenuation coefficient at a point in the sample enables almost exact reconstruction.