Optical Computer Tomography(CT) for Cancer Therapy

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Optical computed tomography (CT) is physically similar to x-ray CT but is more versatile since many powerful light sources exist and optical elements such as mirrors, lenses, polarizers and efficient detectors are available. There are many potential forms of optical CT. Attenuation, fluorescence or scatter, polarization and refractive index spatial changes are all examples of optical CT. To date, optical CT for gel dosimetry has been limited to attenuation measurements that are the sum of scatter and absorption along defined lines.

The use and importance of precision radiotherapy (RT) in cancer treatment have increased greatly over recent decades. A key advance has been the development of techniques whose goal is to deliver dose distributions that are localized at the site of the tumour and shaped to match the tumour. These techniques include both external beam treatments (conformal RT, intensity-modulated RT (Webb 1997) and 'gamma knife' (Friedman and Foote 2000)) and brachytherapy (Vicini et al 1999). Augmented doses at the tumour site and a sparing of healthy tissue are expected to lead to a higher percentage of successful treatments and a reduced rate of complications.

However, increases in local dose and, critically, dose gradient require a more stringent quality assurance (QA) of the treatment planning and delivery. Traditional dosemeters (ion chambers, thermoluminescent devices, diode detectors and film) are not well suited to this task, which demands the following characteristics: (i) non-invasiveness; (ii) high spatial resolution and the ability to measure large number of points simultaneously; (iii) ability to make measurements over arbitrary three-dimensional (3D) regions; (iv) speed, ease of application and automated analysis of data; (v) low enough costs to allow the technique to be taken up by all hospital medical physics departments.

In recent years, magnetic-resonance imaging of gelatin doped with the Fricke solution has been applied to the direct measurement of three-dimensional(3D) radiation dose distributions. However, the 3D dose distribution can also be imaged more economically and efficiently using the method of optical absorption computed tomography. This is accomplished by first preparing a gelatin matrix containing a radiochromic dye and mapping the radiation-induced local change in the optical absorption coefficient. Ferrous-Benzoic-Xylenol(FBX) was the dye of choice for this investigation. The complex formed by Fe3+ and xylenol orange exhibits a linear change in optical attenuation

(cm^{-1}) with radiation dose in the range between 0 and 1000cGy, and the local concentration of this complex can be probed using a green laser (λ=543.5 nm). An optical computed tomography(CT) scanner(Fig 1) was constructed analogous to a first-generation x-ray CT scanner, using a He-Ne laser, photodiodes, and rotation-translation stages controlled by a personal computer. The optical CT scanner itself can reconstruct attenuation coefficients to a baseline accuracy of<2% while yielding dose images accurate to within 5% when other uncertainties are taken into account. Optical Optical tomography is complicated by the reflection and refraction of light rays in the phantom materials, producing a blind spot in the transmission profiles which, results in a significant dose artifact in the reconstructed images. In this report we develop corrections used to reduce this artifact and yield accurate dosimetric maps. In this report we develop corrections used to reduce this artifact and yield accurate dosimetric maps. We also report the chemical reaction kinetics, the dose sensitivity and spatial resolution ~,1 mm3! obtained by optical absorption computed tomography.

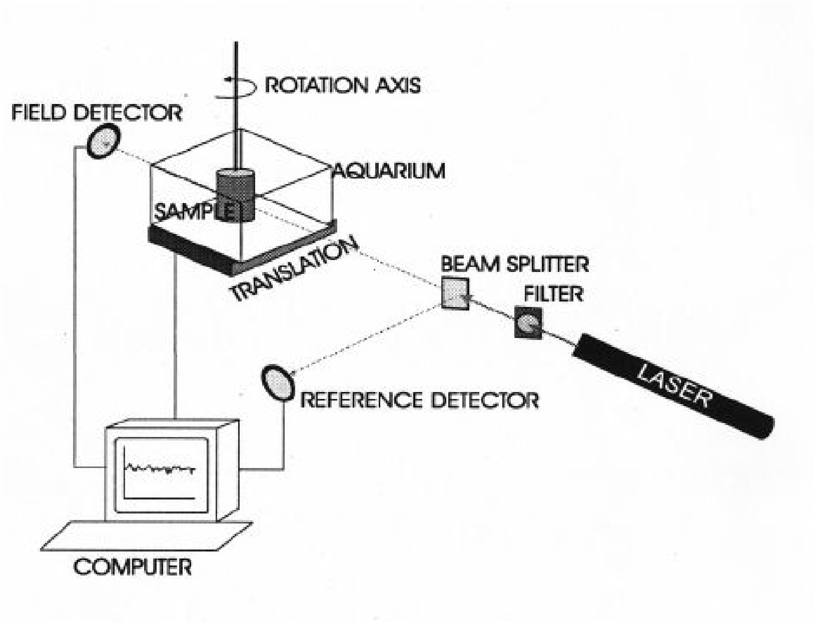

Fig.1 Schematic diagram of apparatus. The He-Ne laser (λ=543.5 nm) and the field detector are positioned at opposite ends of the optical bench with the phantom translating in between. Rotation is facilitated using a rotation platform constructed inside the aquarium.