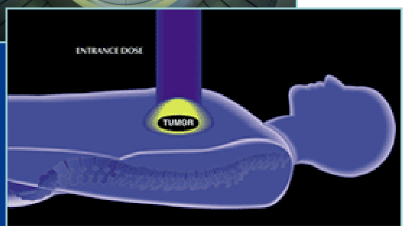
Method for Improving the Accuracy of Charged Particle Beam (High Energy Proton or Carbon Ion Beam) Radiotherapy



A problem with charged particle beam (high energy proton or carbon ion beam) radiotherapy is that doctors use a planning target area larger than the actual target area to make sure the target area gets the appropriate dose. This problem of healthy tissue being irradiated is due to "range uncertainty" of where the target area is, which may be due to physiological causes or radiation set up issues. Our method utilizes fluorescent gold particles implanted within and near tumors that interact with the proton beam to produce fluorescent X-rays. An algorithm then uses the fluorescence emission intensity as an input to determine the charged particle beam trajectory with higher accuracy than is presently possible with current techniques such as "prompt gamma emission" or PET-CT. This technology may minimize "range uncertainties" resulting in less radiation to healthy tissues.

COMMERCIAL OPPORTUNITY

- Proton therapy is an emerging treatment modality for ocular and skull base tumors, sarcomas, pediatric neoplasms and prostate cancer. In 2013, there were 43 facilities worldwide, including 14 in the US, with close to 100,000 patients treated. Although proton therapy is expensive, smaller and cheaper proton accelerators are expected to fuel affordability of this treatment.
- Currently, two technologies are used to minimize the "range uncertainties," PET/CT and Prompt Gamma Emission. PET-CT's main disadvantage is that it must be used after a treatment not during or before treatment, as protons produce slight radioactivity in a patient which are seen using the PET-CT method. Prompt gamma emission's detectors are difficult to use because they are bulky and less sensitive, and the signal is much lower and not as good as fluorescent imaging. Despite their disadvantages, these technologies are still receiving NIH funding due to a strong unmet need.
- This technology exploits the fluorescent intensity of the gold particles, that are routinely implanted in the tumor (normally as a point of reference for routine imaging), to determine the energy, range and 3-dimensional position of a proton beam in the patient during therapy. No method currently exists that calculates all three of these beam measurements at the same time in the patient in real time.

TECHNOLOGY

The invention utilizes gold fluorescent "fiducial markers" implanted within or near the tumor. Upon interaction with the proton beam, the gold particles produce fluorescent X-rays, and an algorithm is used to determine how precisely the proton beam hits the tumor as a function of the fluorescent radiation intensity from gold particles. Numerical Monte-Carlo simulations have been done, as well as analytical theory predictions to show the feasibility of the invention. Moreover, experimental measurements from gold particles in a water phantom (a substitute for tissue) have confirmed these predictions. Therapeutic beams from the UF Proton Therapy Institute were used to excite proton induced x-ray fluorescence emission (PIXE) from cylindrical pure gold fiducial 25 markers. The markers were embedded in a homogeneous water phantom and PIXE was measured using NaI scintillators with energy dispersive spectral analysis. The geometry of the phantom and marker placement was chosen to model parallel-opposed beam treatment of prostate cancer by proton therapy.

PUBLICATION/PATENT

- PCT patent application filed on 1/30/14 for Dr. Brian Tonner

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