Investigation of energy and orientation dependent effects of thimble type ionization detectors in an MRgPT prototype

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Einleitung

Combining MR imaging and beam delivery for image guided precision radiotherapy was already introduced clinically with hybrid MR-linac systems. For proton therapy, given the conformal treatment method as well as the sensitivity to changes in patient anatomy, a hybrid MR and proton therapy device might be even more beneficial. In Dresden, a clinical demonstrator prototype, consisting of an 0.32 T open MR scanner and a horizontal pencil beam scanning beamline was installed. From a medical phyics perspective, the establishment of reliable dosimetry methods is a prerequisite for further pre-clinical and clinical studies.

In MR guided proton therapy (MRgPT), the primary treatment beam itself is influenced by the magnetic field of the scanner. We investigated whether the response of the dosimetry detector depends on the detector orientation with respect to the magnetic field lines.

In this work we focused on potential effects of the 0.32 T magnetic field on commercially available ionization detectors. For photons, considerable

orientation effects have been reported. Given the influence of the magnetic field on the particle trajectories, potential orientation effects could have a considerable influence on dosimetric measurements.

Material und Methode

Experiments were performed at the experimental room of the University Proton Therapy Dresden with and without the prototype MRgPT system positioned 58.2 cm downstream of the beam iso-center of the beam line. Four thimble type ionization detectors, a Farmer, a Semiflex, a PinPoint and a PinPoint 3D detector were positioned at 2 cm water-equivalent depth and irradiated using 10 x 15 cm^2 homogeneous proton fields. Lateral field shifts due to the vertical magnetic field were compensated for. Irradiations were performed for 3 nominal proton energies (100, 150 and 220 MeV) and repeated with the same set-up at 0.32 T (with MR scanner) and 0 T (MR scanner removed). Chambers were positioned in horizontal, vertical and 15° tilted orientation. Magnetic field correction factors were evaluated.

Resultate

Preliminary results show a small orientation dependence within 0.3 and 1% depending on the chamber, with larger effects for smaller chamber volumes.

A small, but consistent energy dependence of the magnetic field correction factor ranging from 0.5 to 1.6% was determined. The change in correction factors was found to be higher for lower energies as well as smaller sensitive detector volumes.

Diskussion

Chamber readings inside an applied magnetic field of 0.32 T were found to depend on detector orientation as well as incident proton energy. For 0 T no noticeable influence was determined. In addition, the effect seems to be more pronounced for small volume chambers. Especially for small volume chambers, such as the PinPoint 3D, it is recommended to introduce a respective correction factor.